

FINAL REPORT  
RTI/1703/00-08F

STUDY OF FALLOUT SHELTER VENTILATION KIT PLACEMENT DESIGN

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LEVEL II

FINAL REPORT RTI/1703/00-08F

# STUDY OF FALLOUT SHELTER VENTILATION KIT PLACEMENT DESIGN

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RESEARCH TRIANGLE INSTITUTE  
OPERATIONS ANALYSIS DIVISION  
APPLIED ECOLOGY DEPARTMENT  
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FINAL REPORT RTI/1703/00-08F

May 1980

Study of Fallout Shelter Ventilation Kit Placement Design

by

S. B. York, III and J. G. Armstrong

for

FEDERAL EMERGENCY MANAGEMENT AGENCY  
Washington, D.C. 20472

under

Contract No. DCPA01-78-C-0318  
FEMA Work Unit 1217G

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Also, ratios of the numbers of PVKs and Kearny pumps needed per 1,000 shelter spaces were developed for each DCPA Region. These ratios could be used to estimate the numbers of PVKs and Kearny pumps required if it is necessary to make procurements and identify warehouse space for a host area before detailed ventilation plans for each shelter facility in that host area have been completed.

In addition, alternative systems for distributing shelter supplies from the host-area county seat to individual shelter facilities were evaluated. Analysis of alternative distribution methods in the Macon, Georgia, and Utica-Rome, New York, host areas indicated that the one truck per shelter facility loaded on the basis of the largest facility first priority method generally should be favored. The logistics involved in implementing this method and the advance planning required were discussed.

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## ABSTRACT

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## I. INTRODUCTION

### A. Report Overview

This is a draft final report by Research Triangle Institute (RTI) on Federal Emergency Management Agency (FEMA) Contract Number DCPA01-78-C-0318, Work Unit 1217G, "Study of Fallout Shelter Ventilation Kit Placement Design." In addition to the following subsection, which provides background information, this report consists of sections that cover objectives, scope, allocation and deployment methodology, regional ventilator requirements, distribution systems, conclusions and recommendations. Section II, Objectives and Scope, provides a more detailed summary of the contents of each report section.

### B. Background

Early in the fallout shelter program, FEMA (formerly the Defense Civil Preparedness Agency [DCPA]) recognized that shelters occupied at the rate of 1 person per 10 square feet of floor area would need to be ventilated in order to maintain a habitable environment. Although experimental data showed that neither carbon dioxide buildup nor oxygen depletion would be problems if as little as 3 cubic feet per minute (cfm) per occupant of fresh air were provided, the heat and moisture given off by shelter occupants would quickly lead to unbearable conditions. In a crisis situation, it is possible that electric power would not be available; therefore, research programs were conducted to identify means of supplying ambient air with manually powered equipment. Through these research programs a pedal-powered axial fan, the Package Ventilation Kit (PVK), and a manually driven Kearney Pump Kit (KPK) were developed to supply and distribute air in shelters. During further research, six basic floor plan configurations were identified as descriptive of National Shelter Survey (NSS) shelters requiring ventilation, and a series



of equipment deployment schemes was developed. A procedure for determining the equipment needs for shelters was included along with a procedure for choosing the appropriate deployment plan. Also, alternative ways of allocating equipment to shelters were investigated.

Recent civil defense thinking has been concentrated on the concept of Crisis Relocation Planning (CRP). Under this concept, in a time of escalating international tensions that could lead to nuclear war, the residents of localities considered likely to receive the direct effects of nuclear weapons would be evacuated to low-risk host areas that are largely rural in nature. Due to the rural nature of these host areas, few NSS spaces have been identified in existing facilities. Therefore, many people would be sheltered in non-NSS facilities in which the fallout protection would be expediently upgraded. In light of this fact and of subsequent civil defense research, many of the results of this early research now need to be reevaluated and updated.

## II. OBJECTIVES AND SCOPE

### A. Objectives

The major objectives of this study are (1) to develop procedures for allocating and deploying PVKs and KPKs in host-area fallout shelters (including illustrative examples of the developed procedures) and (2) to define and evaluate systems for distributing shelter supplies from host-area county seats to individual fallout shelters. Secondary objectives are to develop methods for determining the numbers of PVKs and KPKs required by a host area before it has been surveyed and to evaluate the usefulness of data from the CRP Host Areas Facility Survey for planning ventilation systems in particular fallout shelters.

### B. Scope

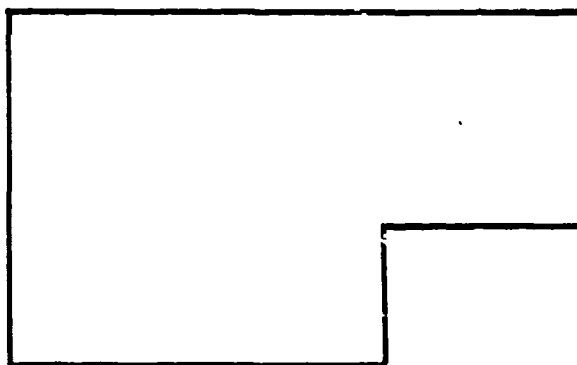
Each of the major and secondary objectives of this study is addressed in a separate chapter or appendix. Chapter 3 contains the development of a stepwise procedure for allocating ventilation kits to an individual shelter facility and for deploying the equipment within the facility. The two types of ventilation kits (PVK and KPK) are described in Appendix A. Appendix B contains example ventilation kit deployment plans for numerous room and aperture configurations and for different sizes of shelter stories. The Appendix B examples are used to develop ventilation equipment planning examples for specific shelter stories (Appendix C). A method for determining regional ventilator requirements is developed in Chapter 4. Alternative systems for distributing fallout shelter supplies from the county seat to individual shelter facilities are evaluated in Chapter 5. The data on shelter facilities in the Macon, Georgia and Utica-Rome, New York Host Areas which serve as bases for the evaluations are displayed in Appendix D. Conclusions and recommendations are made in Chapter 6.

### III. VENTILATION KIT ALLOCATION AND DEPLOYMENT METHODOLOGY

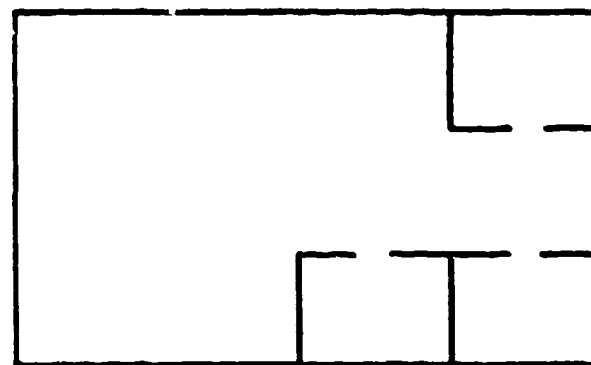
The National Fallout Shelter Survey Program PVK Survey Instruction [1] described a procedure to be followed in defining an emergency ventilation system for NSS facilities. Twenty-inch PVKs were specified to supply air to the shelter. Kearny pumps were not considered for use as air supply or distribution devices.

A subsequent RTI study [2] supplemented and modified the information contained in Reference 1. This study developed a ventilation kit allocation and deployment methodology, with emphasis on the placement of ventilators to minimize duct lengths. Deployment schemes were developed for six basic shelter floor plans that had been identified in an earlier RTI study [3]; these floor plans are illustrated in Figure III-1. The allocation and deployment methodology specified the use of 30-inch PVKs or Kearny pumps to supply air to shelters and the use of Kearny pumps for air distribution.

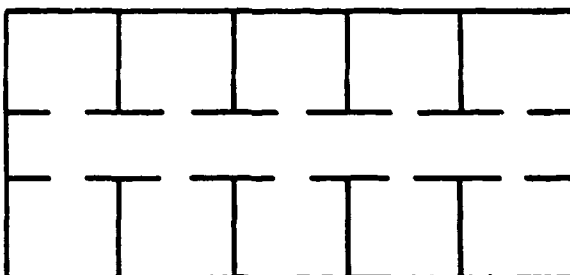
Contained herein are further modifications and refinements to the allocation and deployment methodology reported in Reference 2. These modifications and refinements are a result of several factors. The modifications incorporate information that has been gained from subsequent experimental studies of the use of Kearny pumps to supply air and of the deployment of Kearny pumps to distribute air. The results of experiments performed by RTI have shown that wind can greatly reduce the effectiveness of Kearny pumps as air suppliers [4] and that Kearny pumps should be aligned with the main path of air flow through a shelter to distribute air effectively [5]. Further modifications are due to the shift in emphasis between this and the previous study; i.e., while the previous study emphasized the placement of ventilators to minimize duct length, the present study emphasizes minimizing the number of ventilators needed. This change in emphasis was necessary



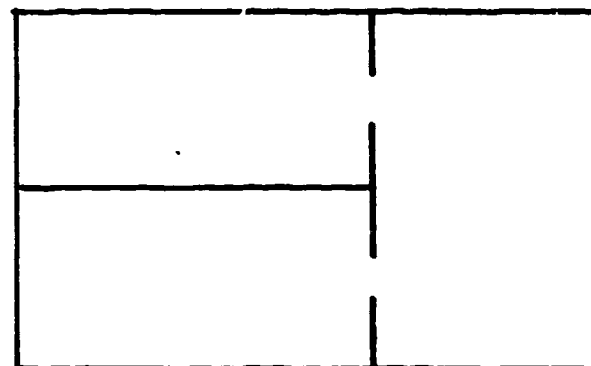
**SINGLE ROOM**



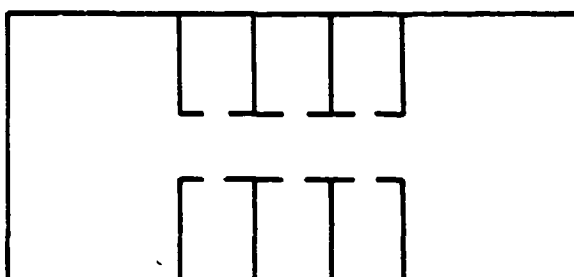
**LARGE AREA WITH SMALL  
ADJOINING ROOMS**



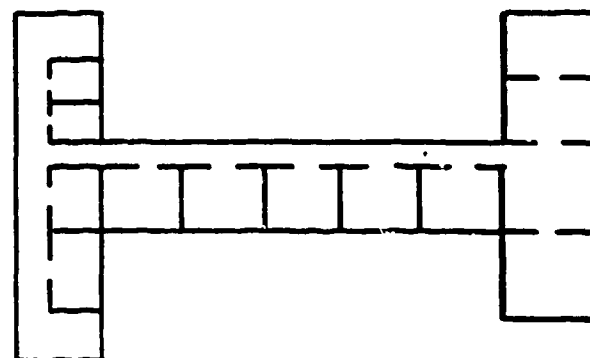
**CORRIDOR WITH ROOMS  
OFF CORRIDOR**



**PARTITIONED INTO ROOMS  
OF COMPARABLE SIZE**



**CORRIDOR (WITH ROOMS OFF IT)  
JOINING TWO LARGE AREAS**



**COMPLEX CONFIGURATION**

**Figure III-1. Six Basic Shelter Configurations**

because the modified methodology is intended for use in developing survey techniques for host-area buildings instead of NSS buildings, as was the case with the previous methodology. Host-area buildings are likely to be smaller and less complex, so the probability of long duct lengths, which significantly reduce the flow of air, should be relatively small. Since the emphasis is on minimizing the numbers of ventilators, all of the required PVKs are illustrated in each example deployment plan. A further refinement is the inclusion of multiple sizes of each floor and aperture configuration, illustrating the effect that shelter story size has on ventilator allocation and deployment.

The steps taken to define a ventilation system are as follows:

- A. Determine maximum shelter story capacity
- B. Determine total airflow requirement
- C. Determine equipment required to supply fresh air
- D. Determine adequacy of apertures
- E. Make adjustments to airflow and, if necessary, repeat Step C
- F. Choose shelter story floor plan and aperture configuration
- G. Determine number of Kearny pumps needed as air mixers
- H. Determine number of Kearny pumps needed to ventilate rooms with no exterior wall apertures
- I. Determine equipment deployment.

Each of these steps is discussed in the following subsections.

A. Determine Maximum Shelter Story Capacity

The maximum shelter story capacity is a function of the usable shelter story area. Procedures are given in Reference 1 for calculating the usable shelter story area. Exceptions to these procedures are (1) that rooms of less than 500 square feet in the shelter area are considered as ventilatable and

(2) that the required volume of ventilation (cfm of air flow) is determined for the entire shelter story rather than for each room separately. The maximum shelter story capacity is found by allowing 10 square feet per person. The actual shelter story capacity may be limited by the adequacy of the apertures, as determined in Step D.

B. Determine Total Airflow Requirement

The total airflow requirement for a shelter story is the product of the number of people to be sheltered (the maximum shelter story capacity from Step A) and the zonal ventilation requirement per person. The zonal ventilation requirement per person is listed in Appendix IV of Reference 1 by state and by county when it varies between counties within a state.

C. Determine Equipment Required to Supply Fresh Air

The type of ventilator used to supply air to a shelter story is dependent on the number of people to be sheltered in that shelter story. A Kearny pump will supply enough air to a shelter story to support 50 or fewer people, regardless of the zonal ventilation requirement. For a shelter story with more than 50 occupants, PVKs should be used to supply fresh air.

The required volume of ventilation (cfm) is determined in Step B. The equivalent duct length should be calculated by following the instructions in Appendix A of this report. When the required volume of ventilation and the equivalent duct length are known, Table III-1 can be used to determine the number of PVKs needed to supply fresh air to the shelter story.

D. Determine Adequacy of Apertures

The following criteria should be considered when the ventilation system for a fallout shelter is being determined; when these criteria are being used, the effect of fallout protection upgrading on the available apertures must be taken into consideration:

TABLE III-1. NUMBER OF PVKS REQUIRED TO SUPPLY  
FRESH AIR TO A SHELTER STORY

Total cfm	Equivalent Duct Length (feet)							
	100	200	300	400	500	600	800	1000
2,000	1	1	1	1	1	1	1	1
2,050	1	1	1	1	1	1	1	2
2,400	1	1	1	1	1	1	2	2
2,800	1	1	1	1	1	2	2	2
3,000	1	1	1	1	2	2	2	2
3,250	1	1	1	2	2	2	2	2
3,500	1	1	2	2	2	2	2	2
3,800	1	2	2	2	2	2	2	2
4,000	2	2	2	2	2	2	2	3
4,800	2	2	2	2	2	2	3	3
5,600	2	2	2	2	2	3	3	3
6,000	2	2	2	2	3	3	3	3
6,150	2	2	2	2	3	3	3	4
6,500	2	2	2	3	3	3	3	4
7,000	2	2	3	3	3	3	3	4
7,200	2	2	3	3	3	3	4	4
7,600	2	3	3	3	3	3	4	4
8,200	2	3	3	3	3	3	4	5
8,400	3	3	3	3	3	4	4	5
9,000	3	3	3	3	4	4	4	5
9,600	3	3	3	3	4	4	5	5
9,750	3	3	3	4	4	4	5	5
10,250	3	3	3	4	4	4	5	6
10,500	3	3	4	4	4	4	5	6
11,200	3	3	4	4	4	5	5	6
11,400	3	4	4	4	4	5	5	6
12,000	3	4	4	4	5	5	6	6
12,300	3	4	4	4	5	5	6	7
12,600	4	4	4	4	5	5	6	7
13,000	4	4	4	5	5	5	6	7
14,000	4	4	5	5	5	6	6	7
14,350	4	4	5	5	5	6	6	8
14,400	4	4	5	5	5	6	7	8
15,000	4	4	5	5	6	6	7	8
15,200	4	5	5	5	6	6	7	8
16,250	4	5	5	6	6	6	7	8
16,400	4	5	5	6	6	6	7	9
16,800	5	5	5	6	6	7	8	9
17,500	5	5	6	6	6	7	8	9
18,000	5	5	6	6	7	7	8	9
18,450	5	5	6	6	7	7	8	10
19,000	5	6	6	6	7	7	8	10
19,200	5	6	6	6	7	7	9	10
19,500	5	6	6	6	7	7	9	10
19,600	5	6	6	7	7	8	9	10
20,500	5	6	6	7	7	8	9	11

(Continued)

TABLE III-1. NUMBER OF PVKS REQUIRED TO SUPPLY  
FRESH AIR TO A SHELTER STORY (Continued)

Total cfm	Equivalent Duct Length (feet)							
	100	200	300	400	500	600	800	1000
21,000	6	6	7	7	8	8	9	11
21,600	6	6	7	7	8	8	10	11
22,400	6	6	7	7	8	9	10	11
22,550	6	6	7	7	8	9	10	12
22,750	6	6	7	8	8	9	10	12
22,800	6	7	7	8	8	9	10	12
24,000	6	7	7	8	9	9	11	12
24,500	6	7	8	8	9	9	11	12
24,600	6	7	8	8	9	9	11	13
25,200	7	7	8	8	9	10	11	13
26,000	7	7	8	9	9	10	11	13
26,400	7	7	8	9	9	10	12	13
26,600	7	8	8	9	9	10	12	13
26,650	7	8	8	9	9	10	12	14
27,000	7	8	8	9	10	10	12	14
28,000	7	8	9	9	10	11	12	14
28,700	7	8	9	9	10	11	12	15
28,800	7	8	9	9	10	11	13	15
29,250	7	8	9	10	10	11	13	15
29,400	8	8	9	10	10	11	13	15
30,000	8	8	9	10	11	11	13	15
30,400	8	9	9	10	11	11	13	15
30,750	8	9	9	10	11	11	13	16
30,800	8	9	9	10	11	12	13	16
31,200	8	9	9	10	11	12	14	16
31,500	8	9	10	10	11	12	14	16
32,500	8	9	10	11	11	12	14	16
32,800	8	9	10	11	11	12	14	17
33,000	8	9	10	11	12	12	14	17
33,600	9	9	10	11	12	13	15	17
34,200	9	10	10	11	12	13	15	17
34,850	9	10	10	11	12	13	15	18
35,000	9	10	11	11	12	13	15	18
35,750	9	10	11	12	12	13	15	18
36,000	9	10	11	12	13	13	16	18
36,400	9	10	11	12	13	14	16	18
36,900	9	10	11	12	13	14	16	19
37,800	10	10	11	12	13	14	16	19
38,000	10	11	11	12	13	14	16	19
38,400	10	11	11	12	13	14	17	19
38,500	10	11	12	12	13	14	17	19
38,950	10	11	12	12	13	14	17	20
39,000	10	11	12	13	14	14	17	20
39,200	10	11	12	13	14	15	17	20
40,800	10	11	12	13	14	15	18	20
41,000	10	11	12	13	14	15	18	21

(Continued)



TABLE III-1. NUMBER OF PVKS REQUIRED TO SUPPLY  
FRESH AIR TO A SHELTER STORY (Continued)

Total cfm	Equivalent Duct Length (feet)							
	100	200	300	400	500	600	800	1000
41,800	10	12	12	14	14	15	18	21
42,000	11	12	13	13	15	16	18	21
42,250	11	12	13	14	15	16	18	21
43,050	11	12	13	14	15	16	18	22
43,200	11	12	13	14	15	16	19	22
44,800	11	12	13	14	15	17	19	22
45,000	11	12	13	14	16	17	19	22
45,100	11	12	13	14	15	17	19	23
45,500	11	12	14	15	16	17	19	23
45,600	11	13	14	15	16	17	20	23
46,200	12	13	14	15	16	17	20	23
47,150	12	13	14	15	16	17	20	24
47,600	12	13	14	15	16	18	20	24
48,000	12	13	14	15	17	18	21	24
48,750	12	13	14	16	17	18	21	24
49,000	12	13	15	16	17	18	21	24
49,200	12	13	15	16	17	18	21	25
49,400	12	14	15	16	17	18	21	25
50,400	13	14	15	16	17	19	22	25
51,000	13	14	15	16	18	19	22	25
51,250	13	14	15	16	18	19	22	26
52,000	13	14	15	17	18	19	22	26
52,500	13	14	16	17	18	19	22	26
52,800	13	14	16	17	18	19	23	26
53,200	13	15	16	17	18	20	23	26
53,300	13	15	16	17	18	20	23	27
54,000	13	15	16	17	19	20	23	27
54,600	14	15	16	17	19	20	23	27
55,200	14	15	16	17	19	20	24	27
55,250	14	15	16	18	19	20	24	27
55,350	14	15	16	18	19	20	24	28
56,000	14	15	17	18	19	21	24	28
57,000	14	16	17	18	20	21	24	28
57,400	14	16	17	18	20	21	24	29
57,600	14	16	17	18	20	21	25	29
58,500	14	16	17	19	20	21	25	29
58,800	15	16	17	19	20	22	25	29
59,450	15	16	17	19	20	22	25	30
59,500	15	16	18	19	20	22	25	30
60,000	15	16	18	19	21	22	26	30
60,800	15	17	18	19	21	22	26	30
61,500	15	17	18	19	21	22	26	31
61,600	15	17	18	19	21	23	26	31
61,750	15	17	18	20	21	23	26	31
62,400	15	17	18	20	21	23	27	31
63,000	16	17	19	20	22	23	27	31

(Continued)

TABLE III-1. NUMBER OF PVKS REQUIRED TO SUPPLY  
FRESH AIR TO A SHELTER STORY (Continued)

Total cfm	Equivalent Duct Length (feet)							
	100	200	300	400	500	600	800	1000
63,550	16	17	19	20	22	23	27	32
64,400	16	17	19	20	22	24	27	32
64,600	16	18	19	20	22	24	27	32
64,800	16	18	19	20	22	24	28	32
65,000	16	18	19	21	22	24	28	32
65,600	16	18	19	21	22	24	28	33
66,000	16	18	19	21	23	24	28	33
66,500	16	18	20	21	23	24	28	33
67,200	17	18	20	21	23	25	29	33
67,650	17	18	20	21	23	25	29	34
68,250	17	18	20	22	23	25	29	34
68,400	17	19	20	22	23	25	29	34
69,000	17	19	20	22	24	25	29	34
69,600	17	19	20	22	24	25	30	34
69,700	17	19	20	22	24	25	30	35
70,000	17	19	21	22	24	26	30	35
71,400	18	19	21	22	24	26	30	35
71,500	18	19	21	23	24	26	30	35
71,750	18	19	21	23	24	26	30	36
72,000	18	19	21	23	25	26	31	36
72,200	18	20	21	23	25	26	31	36
72,800	18	20	21	23	25	27	31	36
73,500	18	20	22	23	25	27	31	36
73,800	18	20	22	23	25	27	31	37
74,400	18	20	22	23	25	27	32	37
74,750	18	20	22	24	25	27	32	37
75,000	18	20	22	24	26	27	32	37
75,600	19	20	22	24	26	28	32	37
75,850	19	20	22	24	26	28	32	38
76,000	19	21	22	24	26	28	32	38
76,800	19	21	22	24	26	28	33	38
77,000	19	21	23	24	26	28	33	38
77,900	19	21	23	24	26	28	33	39
78,000	19	21	23	25	27	28	33	39
78,400	19	21	23	25	27	29	33	39
79,200	19	21	23	25	27	29	34	39
79,800	20	22	23	25	27	29	34	39
79,950	20	22	23	25	27	29	34	40

- When PVK(s) are used to ventilate a shelter, an aperture area equal to the cross-sectional area of the duct(s) (4.9 square feet per duct) must be present to accommodate the exhaust ducts, and an equal area must be available for air inlets to allow the ventilators to move the rated capacity of air. Figure III-2 illustrates this point.
- When a Kearny pump is used to ventilate a shelter, an aperture area equal to one-half the area of a Kearny pump (7.5 square feet for a 6-foot Kearny pump) must be present as an exhaust, and an equal area must be available to serve as an air inlet to allow for the maximum passage of air. Figure III-3 illustrates this situation.
- When it is necessary for air to enter a shelter through apertures remotely located from the ventilator, any apertures that are very close to the ventilator should be closed or opened only slightly. Figure III-4 presents an example of this type of floor plan and aperture configuration.
- If a 6-foot Kearny pump is to be used to ventilate a shelter, a standard doorway must be available for use. An aperture with dimensions at least three feet square must be available for the use of a 3-foot Kearny pump.

E. Make Adjustments to Airflow and, if Necessary, Repeat Step C

If the aperture area along the route of the air flow is not sufficient to permit the use of the number of ventilators required to supply air for the maximum shelter story capacity, the maximum air flow that can be handled by the existing apertures should be computed by an experienced engineer or technician. Then the shelter story capacity should be adjusted downward accordingly.

F. Choose Shelter Story Floor Plan and Aperture Configuration

Table III-2 presents the codes for shelter story floor plan and aperture configurations. The shelter story floor plan selected from the list should be that which most nearly approximates the shelter being considered. Very small rooms such as closets should be ignored in this procedure. After the floor plan has been determined, the aperture configuration that most nearly approximates the apertures in the shelter under consideration is selected. In

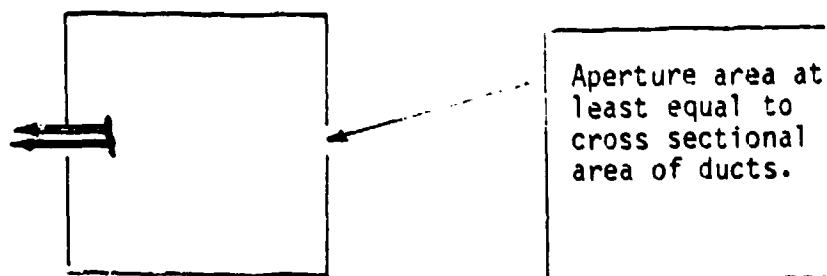


Figure III-2

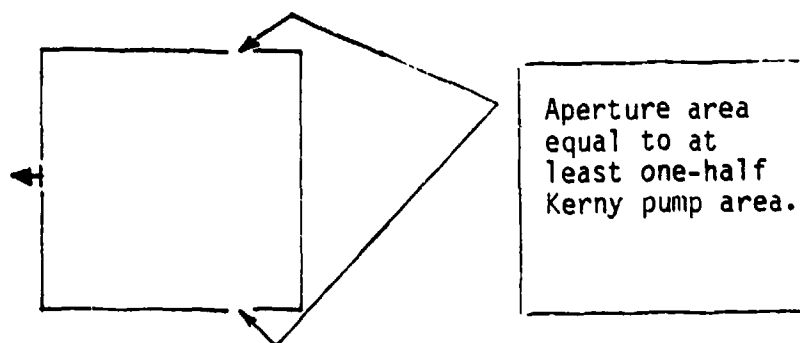


Figure III-3

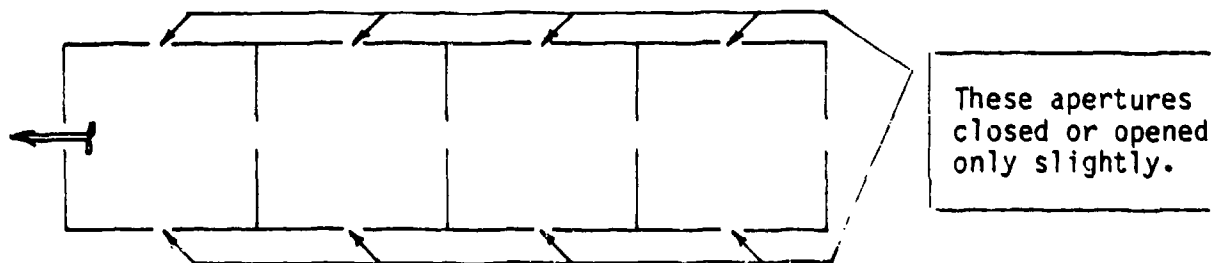


Figure III-4

TABLE III-2. CODES FOR SHELTER STORY FLOOR PLAN  
AND APERTURE CONFIGURATIONS

Code	Configuration
I-A.	Single room.
1.	Multiple apertures per wall in at least two walls directly opposite each other.
2.	Single apertures in two walls directly opposite each other.
3.	Apertures in two adjacent walls.
4.	Multiple apertures in only one wall.
5.	Only one aperture in one wall.
I-B.	Single room with one much smaller room.
1.	No apertures in small room.
a.	Apertures in at least two walls directly opposite each other in large room.
b.	Single apertures in two walls directly opposite each other in large room.
c.	Apertures in two adjacent walls of large room.
d.	Multiple apertures in only one wall of large room.
e.	Only one aperture in one wall of large room.
2.	Apertures in small room.
a.	Apertures in the wall of large room directly opposite the wall adjoining the small room.
b.	Multiple apertures per wall in two walls of large room directly opposite each other.
c.	Multiple apertures in only one wall of large room.
d.	No apertures in large room.
I-C.	Winding Corridor.
1.	Apertures in or near each end of corridor.
2.	Apertures in or near one end of corridor and on at least one side.
3.	Apertures in side walls of corridor but not near the ends.
4.	Apertures in or near one end only.

(Continued)

TABLE III-2. CODES FOR SHELTER STORY FLOOR PLAN  
AND APERTURE CONFIGURATIONS (Continued)

Code	Configuration
II-A.	Large area with small adjoining rooms.
1.	Apertures in all small rooms and in large area.
2.	Apertures in large area and some of small rooms.
3.	No apertures in small rooms.
a.	Apertures in two walls of large area directly opposite each other.
b.	Apertures in two adjacent walls of large area.
c.	Multiple apertures in only one wall of large area.
d.	Single aperture in one wall of large area.
4.	Apertures in all small rooms, none in large area.
5.	Apertures in some small rooms, none in large area.
III-A.	Partitioned into rooms of comparable size (two rooms).
1.	Apertures in both rooms in wall opposite common wall.
2.	Apertures in both rooms but not in wall opposite common wall.
3.	Apertures in one room only.
a.	Multiple apertures in two walls directly opposite each other.
b.	Apertures in two adjacent walls.
c.	Multiple apertures in only one wall.
d.	Single aperture in only one wall.
III-B.	Partitioned into rooms of comparable size (three rooms in series).
1.	Apertures in walls of both end rooms.
2.	Apertures in one end room and in middle room.
3.	Apertures in middle room only.
4.	Apertures in one end room only.
III-C.	Partitioned into rooms of comparable size (three rooms not in series).
1.	Apertures in all three rooms.
2.	Apertures in only two rooms.
3.	Apertures in only one room.

(Continued)

TABLE III-2. CODES FOR SHELTER STORY FLOOR PLAN  
AND APERTURE CONFIGUATIONS (Continued)

Code	Configuration
III-D.	Partitioned into rooms of comparable size (four or more rooms in series).
1.	Apertures in both end rooms.
2.	Apertures in one end room and all middle rooms; or in one end room and the middle room adjacent to the other end room.
3.	Apertures in one end room and the adjacent room only, or in one end room only.
4.	Apertures in middle rooms only.
5.	Aperture not in all middle rooms and not in end rooms.
III-E.	Partitioned into rooms of comparable size (four or more rooms not in series).
1.	Apertures in all rooms.
2.	Apertures not in all rooms.
IV-A.	Corridor with rooms off corridor.
1.	Apertures in the corridor and in all or part of the rooms.
2.	Apertures in all or part of rooms but not in corridor.
3.	Apertures in corridor only.
V-A.	Corridor (with rooms off it) joining two large areas.
1.	Apertures in both large areas and in all small rooms.
2.	Apertures in all of the small rooms and none in large areas or corridor.
3.	Apertures in some of the small rooms, but none in corridor and one or both of large areas.
VI.	<p>Complex configuration with large number of rooms that form combinations of the preceding categories.</p> <p>When this configuration is encountered, the shelter should be divided into parts, each of which conforms to one of the preceding definitions. These parts should then be analyzed separately to determine the ventilation requirements. However, it should be kept in mind that two or more of these parts may be considered together when the ventilation equipment needs and equipment deployment are defined.</p>

evaluating the aperture configuration, the effect that fallout protection upgrading will have must be taken into account. Also, if there are areas in the shelter that cannot be fully used because of a lack of ventilation, the feasibility of creating apertures in interior partitions or exterior walls should be investigated. The code number listed by each of the configurations is also used to identify recommended deployment procedures in Step I.

G. Determine Number of Kearny Pumps Needed as Air Mixers

In this study, because of the relatively short effective duct lengths encountered in host-area shelters, deployment plans are developed so as to minimize the number of ventilators required. PVKs should be placed to distribute air, as well as to exhaust stale air from the shelter. Therefore, the number of Kearny pumps needed to distribute air is the total number of ventilators needed for proper air mixing minus the number of PVKs required (as calculated in Step C) to satisfy the total airflow requirement.

Ventilators are needed to mix the air in large unpartitioned areas, particularly areas about which the apertures are poorly distributed. A 3-foot Kearny pump will properly distribute the air over an area of approximately 1,000 square feet [6]. Consequently, for large open areas with poorly distributed apertures, one ventilator is allocated per 1,000 square feet of floor area. For large open areas with well-dispersed apertures, the fresh air should be better distributed such that one ventilator is allocated for each 2,000 square feet of floor area. These should be used only as general guidelines. Each shelter story must be treated as a unique case in identifying specific ventilator requirements.

Kearny pumps are much more effective in distributing air in a shelter if they are aligned so that they move air in the same direction as the main path of airflow through the shelter. Kearny pumps are effective in moving air up to 50 or 60 feet outside the normal path of airflow through the shelter [5].



H. Determine Number of Kearny Pumps Needed to Ventilate Rooms with No Exterior Wall Apertures

If no PVK is placed in a room without exterior wall apertures, fresh air must be provided by a Kearny pump if the room is to be usable as shelter. A room that is connected to a ventilated area by a single doorway may be ventilated by placing a 3-foot Kearny pump in the top half of the doorway. The maximum airflow delivered to the windowless room by this procedure is 590 cfm [6]. If two or more doorways connect the windowless room and the ventilated area, the windowless room can be ventilated by a 6-foot Kearny pump placed in one of the doorways. The maximum airflow provided to the windowless room in this case is 3,700 cfm [2].

I. Determine Equipment Deployment

Appendix B of this report contains example ventilation equipment deployment plans that can be used as guidance in specifying deployment schemes for host-area shelters. The code number listed by each of the configurations corresponds to the code number described in Table II-2. The following paragraphs present factors to consider when the example deployment plans are used to develop and implement a ventilation plan for a specific host-area shelter story.

The equipment allocations illustrated in the examples are based on a zonal ventilation requirement of 15 cfm per person. More Kearny pumps may be needed in areas requiring less than 15 cfm per person because relatively fewer PVKs will be required and the airflow will be at a lower velocity. Similarly, fewer Kearny pumps may be needed in areas requiring more than 15 cfm per person.

Most of the illustrations show exterior wall apertures as means of supplying and exhausting air. If it is necessary or desirable to use stairways or elevator shafts in a ventilation system, they may be considered

in the same manner as exterior wall apertures. However, when stairways or elevator shafts are used to supply or exhaust air to another story, air should not be drawn from or exhausted to another shelter area. Furthermore, it is necessary to make sure that air exhausted to another story is not recirculated back into the ventilating system. This consideration also applies to air exhausted from any shelter story to the outside, particularly in shelter stories with only one aperture. In this case, when a PVK is used to exhaust the air, the duct should extend at least 35 feet beyond the aperture [7].

Because exhaust systems are usually the most effective means of ventilation, exhaust systems are illustrated in the Appendix B examples with a few exceptions. Kearny pumps are shown supplying air to small shelter stories in which there would be no flow through ventilation because of the aperture configuration. A supply system also would be more effective than an exhaust system in some larger shelter stories, but this determination must be made at the shelter site.

#### IV. DETERMINATION OF REGIONAL VENTILATOR REQUIREMENTS

It is likely that FEMA will initiate procurement of ventilation equipment before information is available upon which to base estimates of the numbers of PVKs and Kearny pumps needed. Therefore, the following analysis is intended to provide a general basis for making the procurements as a function of the number of people to be sheltered. Factors other than the number of people to be sheltered that are considered in performing the analysis include the following:

- Distribution of shelter stories by room configuration
- Distribution of shelter stories by size
- Percentage of shelter stories in basements and first floors
- Distribution of shelter stories by zonal ventilation requirement.

A shelter's room configuration affects the distribution of air and, therefore, the need for Kearny pumps. Information about the distribution of shelter stories by room configuration in host-area facilities presently is not available. The shelter sketches that are made when the facilities are surveyed in the host-area survey show only exterior dimensions; interior partitions and the locations of apertures are not required. However, in a previous study [8], RTI estimated the distribution of NSS shelter stories requiring ventilation according to shelter configuration. This distribution is shown in Table IV-1. Although the distribution of host-area shelter facilities probably has more simple configurations than does the NSS distribution, the requirements for PVKs and Kearny pumps derived from this distribution should be good indications of the actual numbers needed in the host areas and should be particularly useful in identifying regional differences in requirements.

TABLE IV-1. ESTIMATED DISTRIBUTION OF NSS SHELTER STORIES REQUIRING  
VENTILATION ACCORDING TO SHELTER CONFIGURATION

Shelter Configuration Category	Estimated Percent of Total Stories
1. Basic single room	
a. Single room	.2517
b. Single room + 1 much smaller room	.0699
c. Winding corridor	.0070
2. Large area with small adjoining rooms	.1469
3. Partitioned into rooms of comparable size	
a. Two rooms	.0629
b. Three rooms	.1469
c. Four rooms	.0070
d. More than four rooms	.0280
4. Corridor with rooms off corridor	.0909
5. Corridor (with rooms off it) joining 2 large areas	.1329
6. Complex configuration with large number of rooms that form combinations of the preceeding categories	.0559
TOTAL	1.0000

Both the distribution of shelter stories by size and the percentage of shelter stories in basements and first floors were provided by FEMA, reported by DCPA Region. The number of PVKs needed to ventilate a shelter story is a function of the story size. Whether a shelter story is in a basement or on a first floor impacts both the distribution of apertures and the requirement for Kearny pumps. The subsequent analysis is done on the basis of shelter stories rather than on the basis of shelter facilities because, in the design of ventilation systems for shelter facilities with more than one shelter story, each story should be treated independently. Table IV-2 displays the distribution of shelter stories by size and DCPA Region, and Table IV-3 presents the percentages of shelter stories in basements and first floors by DCPA Region.

The distribution of shelter stories by zonal ventilation requirement (the requirement for PVKs is a function of the zonal ventilation requirement) was estimated from the distribution of population by zonal ventilation requirement. The zonal ventilation requirement for each state (or group of counties in a state with more than one zonal ventilation requirement) was extracted from the NSS PVK Survey Instructions [1]. Census of Population data [9] were used to determine the number of people living in each zone. Table IV-4 displays the distribution of population by ventilation zone for each DCPA Region. In estimations of the distribution of shelter stories by zonal ventilation requirement, it was assumed that the shelter story distribution would be the same as the population distribution.

In order to estimate the numbers of PVKs and Kearny pumps needed in each region, the numbers of PVKs needed for each configuration as a function of zonal ventilation requirement and story size was calculated. Table IV-5 displays this information. The numbers of Kearny pumps needed were calculated

TABLE IV-2. DISTRIBUTION OF SHELTER STORIES BY SIZE AND DCPA REGION

Spaces	DCPA Region							
	1	2	3	4	5	6	7	8
1-50	6,953	3,687	3,093	10,862	2,776	2,543	2,360	567
51-100	13,906	8,111	12,371	25,345	9,715	6,357	7,079	1,842
101-200	17,698	10,692	22,423	36,207	18,737	12,290	10,619	3,542
201-300	8,217	4,793	12,371	16,897	11,103	6,781	5,899	2,409
301-400	4,424	2,581	6,959	9,655	6,246	3,814	3,933	1,417
401-500	2,528	1,475	4,639	4,828	4,164	2,543	2,360	992
501-600	1,896	1,106	3,093	3,621	3,470	1,695	1,573	708
601-700	1,264	737	2,320	2,414	2,082	1,271	1,180	425
701-800	632	369	1,546	2,414	2,082	848	787	283
801-900	632	369	1,546	1,207	1,388	848	787	283
901-1,000	632	369	773	1,207	694	424	393	142
1,001-1,100	632	369	773	1,207	694	424	393	142
1,101-1,200	632	369	773	1,207	694	424	393	142
1,201-1,300	0	369	773	0	694	424	393	142
1,301-1,400	0	0	773	0	694	0	0	142
1,401-1,500	0	0	0	0	694	0	0	0
1,501-1,600	0	0	0	0	694	0	0	142
1,601-1,700	0	0	0	0	0	0	0	0
1,701-1,800	0	0	0	0	0	0	0	0
1,801-1,900	0	0	0	0	0	0	0	0
1,901-2,000	0	0	0	0	0	0	0	0
2001+	1,896	737	2,320	2,414	2,082	848	787	567
Total	61,942	36,133	76,546	119,485	68,703	41,534	38,936	13,887

TABLE IV-3. PERCENTAGES OF HOST-AREA SHELTER STORIES IN BASEMENTS  
AND FIRST STORIES BY DCPA REGION

DCPA Region	Percentage of Shelter Stories in Basements	Percentage of Shelter Stories on First Floor
1	24.45	75.55
2	20.59	79.41
3	5.28	94.72
4	22.70	77.30
5	5.16	94.84
6	25.26	74.74
7	2.22	97.78
8	13.08	86.92

TABLE IV-4. REGIONAL DISTRIBUTION OF POPULATION BY  
ZONAL VENTILATION REQUIREMENT

DCPA Region	Zonal Ventilation Requirement (cfm)	Population	Percent of Regional Population
1	8	1,557,405	4.2
	10	33,808,530	90.8
	15	1,880,859	5.0
	Total	37,246,794	100.0
2	10	8,936,070	38.2
	15	14,477,583	61.8
	Total	23,413,653	100.0
3	15	13,811,818	43.6
	20	10,994,561	34.7
	25	4,234,290	13.4
	30	2,644,237	8.3
	Total	31,684,906	100.0
4	8	4,911,041	11.1
	10	34,144,479	77.5
	15	5,001,927	11.4
	Total	44,057,447	100.0
5	8	444,906	2.2
	10	1,243,057	6.1
	15	1,139,736	5.6
	20	4,375,721	21.5
	25	3,848,523	18.9
	30	3,801,497	18.7
	40	4,665,738	22.9
	50	817,382	4.0
	Total	20,336,560	99.9
6	8	5,388,319	32.1
	10	3,084,198	18.4
	15	8,234,874	49.0
	20	100,182	0.6
	Total	16,807,573	100.1
7	8	7,968,965	35.9
	10	11,120,650	50.1
	15	2,094,808	9.4
	20	1,028,349	4.6
	Total	22,212,772	100.0
8	8	6,213,121	100.0
Total		201,972,826	



TABLE IV-5. NUMBER OF PVKS\* REQUIRED TO VENTILATE A SHELTER STORY  
AS A FUNCTION OF ZONAL VENTILATION REQUIREMENT AND STORY SIZE

Spaces	Zonal Ventilation Requirement (cfm)							
	8	10	15	20	25	30	40	50
50	0	0	0	0	0	0	0	0
100	1	1	1	1	1	1	2	2
200	1	1	1	2	2	2	3	3
300	1	1	2	2	2	3	4	4
400	1	2	2	3	3	4	5	6
500	2	2	2	3	4	4	6	7
600	2	2	3	4	4	5	7	8
700	2	2	3	4	5	6	8	10
800	2	3	4	5	6	7	9	11
900	2	3	4	5	6	8	10	12
1,000	3	3	4	6	7	8	11	14
1,100	3	3	5	6	8	9	12	15
1,200	3	4	5	7	8	10	13	16
1,300	3	4	6	7	9	11	14	18
1,400	3	4	6	8	10	12	15	19
1,500	4	4	6	8	10	12	16	20
1,600	4	5	7	9	11	13	17	22
3,000	7	8	12	16	20	24	32	40

\*Assuming an equivalent duct length of 200 feet (all of the duct in the PVK used).

as a function of shelter configuration and basement or first-story as well as zonal ventilation requirement and story size. Tables IV-6 through IV-16 show the requirements for Kearny pumps for each configuration presented in Table IV-1.

In order to estimate the number of PVKs and Kearny pumps needed as a function of the number of people to be sheltered, it was necessary to develop several general guidelines and specific assumptions. The following general guidelines applying to all room configurations (listed in Table IV-2) were adhered to in developing the Regional numbers of PVKs and Kearny pumps:

- One Kearny pump can be used to supply air to a shelter story with 50 spaces or less.
- One Kearny pump per 2,000 square feet of unpartitioned area is needed to distribute air in a first-floor story (widely separated apertures of adequate size are or can be made available).
- One Kearny pump per 1,000 square feet of unpartitioned area is needed to distribute air in a basement story.
- Basement rooms off large areas or corridors are dead-end rooms.
- One Kearny pump or PVK ventilates at most two adjacent dead-end rooms (an aperture can be made in the wall between them).
- A PVK can be placed to distribute air (instead of a Kearny pump) as well as to exhaust stale air, reducing the requirement for Kearny pumps in shelters needing several PVKs.

The following assumptions pertaining to specific room configurations were made in developing the Regional numbers of PVKs and Kearny pumps:

- The small room in Configuration 1b consists of 25 percent of the area of the large room.
- The large area in Configuration 2 consists of 50 percent of the total area of the story.
- The remaining 50 percent of Configuration 2 is partitioned as follows: 100 spaces, 3 rooms; 200 to 300 spaces, 4 rooms; 400 to 500 spaces, 5 rooms; 600 to 700 spaces, 6 rooms; 800 to 900 spaces, 7 rooms; 1,000 to 1,100 spaces, 8 rooms; 1,200 to 1,300 spaces, 9 rooms; 1,400 to 1,500 spaces, 10 rooms; 1,600 spaces, 11 rooms; and 3,000 spaces, 18 rooms.

TABLE IV-6. THE NUMBER OF KEARNY PUMPS REQUIRED TO DISTRIBUTE AIR IN A CONFIGURATION 1a SHELTER STORY AS A FUNCTION OF ZONAL VENTILATION REQUIREMENT, STORY SIZE, AND BASEMENT OR FIRST-FLOOR STORY

Spaces	Zonal Ventilation Requirement (cfm)															
	8		10		15		20		25		30		40		50	
	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base
50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0
300	0	2	0	2	0	1	0	1	0	1	0	0	0	0	0	0
400	1	3	0	2	0	2	0	1	0	1	0	0	0	0	0	0
500	0	3	0	3	0	3	0	2	0	1	0	1	0	0	0	0
600	1	4	1	4	0	3	0	2	0	2	0	1	0	0	0	0
700	1	5	1	5	0	4	0	3	0	2	0	1	0	0	0	0
800	2	6	1	5	0	4	0	3	0	2	0	1	0	0	0	0
900	2	7	1	6	0	5	0	4	0	3	0	1	0	0	0	0
1,000	2	7	2	7	1	6	0	4	0	3	0	2	0	0	0	0
1,100	2	8	2	8	0	6	0	5	0	3	0	2	0	0	0	0
1,200	3	9	2	8	1	7	0	5	0	4	0	2	0	0	0	0
1,300	3	10	2	9	0	7	0	6	0	4	0	2	0	0	0	0
1,400	4	11	3	10	1	8	0	6	0	4	0	2	0	0	0	0
1,500	3	11	3	11	1	9	0	7	0	5	0	3	0	0	0	0
1,600	4	12	3	11	1	9	0	7	0	5	0	3	0	0	0	0
3,000	8	23	7	22	3	18	0	14	0	10	0	6	0	0	0	0

TABLE IV-7. THE NUMBER OF KEARNY PUMPS REQUIRED TO DISTRIBUTE AIR IN A CONFIGURATION 1b SHELTER STORY AS A FUNCTION OF ZONAL VENTILATION REQUIREMENT, STORY SIZE, AND BASEMENT OR FIRST-FLOOR STORY

Spaces	Zonal Ventilation Requirement (cfm)															
	8		10		15		20		25		30		40		50	
	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base
50	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0
300	0	2	0	2	0	1	0	1	0	1	0	0	0	0	0	0
400	0	3	0	2	0	2	0	1	0	1	0	0	0	0	0	0
500	0	3	0	3	0	3	0	2	0	1	0	1	0	0	0	0
600	0	3	0	3	0	2	0	1	0	1	0	0	0	0	0	0
700	0	4	0	4	0	3	0	2	0	1	0	0	0	0	0	0
800	1	5	0	4	0	3	0	2	0	1	0	0	0	0	0	0
900	1	6	0	5	0	4	0	3	0	2	0	0	0	0	0	0
1,000	2	7	2	7	1	6	0	4	0	3	0	2	0	0	0	0
1,100	2	7	2	7	0	5	0	4	0	2	0	1	0	0	0	0
1,200	2	8	1	7	0	6	0	4	0	3	0	1	0	0	0	0
1,300	3	9	2	8	0	6	0	5	0	3	0	1	0	0	0	0
1,400	3	10	2	9	0	7	0	5	0	3	0	1	0	0	0	0
1,500	3	11	3	11	1	9	0	7	0	5	0	3	0	0	0	0
1,600	3	11	2	10	0	8	0	6	0	4	0	2	0	0	0	0
3,000	8	23	7	22	3	18	0	14	0	10	0	6	0	0	0	0

TABLE IV-8. THE NUMBER OF KEARNY PUMPS REQUIRED TO DISTRIBUTE AIR IN A CONFIGURATION 1c SHELTER STORY AS A FUNCTION OF ZONAL VENTILATION REQUIREMENT, STORY SIZE, AND BASEMENT OR FIRST-FLOOR STORY

Spaces	Zonal Ventilation Requirement (cfm)															
	8		10		15		20		25		30		40		50	
	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base
50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
700	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE IV-9. THE NUMBER OF KEARNY PUMPS REQUIRED TO DISTRIBUTE AIR IN A CONFIGURATION 2 SHELTER STORY AS A FUNCTION OF ZONAL VENTILATION REQUIREMENT, STORY SIZE, AND BASEMENT OR FIRST-FLOOR STORY

Spaces	Zonal Ventilation Requirement (cfm)															
	8		10		15		20		25		30		40		50	
	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base
50	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
100	0	2	0	2	0	2	0	2	0	2	0	2	0	1	0	1
200	0	4	0	4	0	4	0	3	0	3	0	3	0	2	0	2
300	0	4	0	4	0	3	0	3	0	3	0	2	0	1	0	1
400	0	6	0	5	0	5	0	4	0	4	0	3	0	2	0	1
500	0	5	0	5	0	5	0	4	0	3	0	3	0	1	0	0
600	0	7	0	7	0	6	0	5	0	5	0	4	0	2	0	1
700	0	7	0	7	0	6	0	5	0	4	0	3	0	1	0	0
800	0	9	0	8	0	7	0	6	0	5	0	4	0	2	0	0
900	0	9	0	8	0	7	0	6	0	5	0	3	0	1	0	0
1,000	0	10	0	10	0	9	0	7	0	6	0	5	0	2	0	0
1,100	0	10	0	10	0	8	0	7	0	5	0	4	0	1	0	0
1,200	0	12	0	11	0	10	0	8	0	7	0	5	0	2	0	0
1,300	0	12	0	11	0	9	0	8	0	6	0	4	0	1	0	0
1,400	0	14	0	13	0	11	0	9	0	7	0	5	0	2	0	0
1,500	0	13	0	13	0	11	0	9	0	7	0	5	0	1	0	0
1,600	0	15	0	14	0	12	0	10	0	8	0	6	0	2	0	0
3,000	0	26	0	25	0	21	0	17	0	13	0	9	0	1	0	0

TABLE IV-10. THE NUMBER OF KEARNY PUMPS REQUIRED TO DISTRIBUTE AIR IN A CONFIGURATION 3a SHELTER STORY AS A FUNCTION OF ZONAL VENTILATION REQUIREMENT, STORY SIZE, AND BASEMENT OR FIRST-FLOOR STORY

Spaces	Zonal Ventilation Requirement (cfm)															
	8		10		15		20		25		30		40		50	
	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base
50	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0
300	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0
400	1	3	0	2	0	2	0	1	0	0	0	0	0	0	0	0
500	0	2	0	2	0	2	0	2	0	2	0	1	0	0	0	0
600	0	4	0	4	0	3	0	2	0	1	0	0	0	0	0	0
700	0	4	0	4	0	3	0	3	0	2	0	1	0	0	0	0
800	2	6	1	5	0	4	0	3	0	2	0	0	0	0	0	0
900	2	6	1	5	0	4	0	4	0	3	0	2	0	0	0	0
1,000	1		1	7	0	6	0	4	0	2	0	1	0	0	0	0
1,100	1		1	7	0	5	0	5	0	4	0	2	0	0	0	0
1,200	3	9	2	8	1	7	0	5	0	3	0	1	0	0	0	0
1,300	3	9	2	8	0	6	0	6	0	4	0	2	0	0	0	0
1,400	3	11	2	10	0	8	0	6	0	4	0	2	0	0	0	0
1,500	2	11	2	10	0	9	0	7	0	5	0	3	0	0	0	0
1,600	4	12	3	11	1	18	0	14	0	10	0	6	0	0	0	0
3,000	7	23	6	22	2											

TABLE IV-11. THE NUMBER OF KEARNY PUMPS REQUIRED TO DISTRIBUTE AIR IN A CONFIGURATION 3b SHELTER STORY AS A FUNCTION OF ZONAL VENTILATION REQUIREMENT, STORY SIZE, AND BASEMENT OR FIRST-FLOOR STORY

Spaces	Zonal Ventilation Requirement (cfm)															
	8		10		15		20		25		30		40		50	
	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base
50	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3
100	0	1	0	1	0	1	0	1	0	1	0	1	0	0	0	0
200	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0
300	0	2	0	2	0	1	0	1	0	1	0	0	0	0	0	0
400	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0
500	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0
600	1	4	1	4	0	3	0	2	0	2	0	1	0	0	0	0
700	1	4	1	4	0	3	0	2	0	1	0	0	0	0	0	0
800	1	4	0	3	0	2	0	1	0	0	0	0	0	0	0	0
900	1	7	0	6	0	5	0	4	0	3	0	1	0	0	0	0
1,000	2	6	0	6	0	5	0	3	0	2	0	1	0	0	0	0
1,100	2	6	0	6	0	4	0	3	0	1	0	0	0	0	0	0
1,200	3	9	2	8	1	7	0	5	0	4	0	2	0	0	0	0
1,300	3	9	2	8	0	6	0	5	0	3	0	1	0	0	0	0
1,400	3	9	2	8	0	6	0	4	0	2	0	0	0	0	0	0
1,500	2	11	2	11	0	9	0	7	0	5	0	3	0	0	0	0
1,600	2	11	1	10	0	8	0	6	0	4	0	2	0	0	0	0
3,000	8	23	7	22	3	18	0	14	0	10	0	6	0	0	0	0



TABLE IV-12. THE NUMBER OF KEARNY PUMPS REQUIRED TO DISTRIBUTE AIR IN A CONFIGURATION 3c SHELTER STORY AS A FUNCTION OF ZONAL VENTILATION REQUIREMENT, STORY SIZE, AND BASEMENT OR FIRST-FLOOR STORY

Spaces	Zonal Ventilation Requirement (cfm)															
	8		10		15		20		25		30		40		50	
	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base
50	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
100	0	2	0	2	0	2	0	2	0	2	0	2	0	0	0	0
200	0	2	0	2	0	2	0	0	0	0	0	0	0	0	0	0
300	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0
400	0	3	0	2	0	2	0	1	0	1	0	0	0	0	0	0
500	0	2	0	2	0	2	0	1	0	0	0	0	0	0	0	0
600	0	2	0	2	0	1	0	0	0	0	0	0	0	0	0	0
700	0	2	0	2	0	1	0	0	0	0	0	0	0	0	0	0
800	2	6	1	5	0	4	0	3	0	2	0	1	0	0	0	0
900	2	6	1	5	0	4	0	3	0	2	0	0	0	0	0	0
1,000	1	5	1	5	0	4	0	2	0	1	0	0	0	0	0	0
1,100	1	5	1	5	0	3	0	2	0	0	0	0	0	0	0	0
1,200	1	9	0	8	0	7	0	5	0	4	0	2	0	0	0	0
1,300	1	9	0	8	0	6	0	5	0	3	0	1	0	0	0	0
1,400	1	9	0	8	0	6	0	4	0	2	0	0	0	0	0	0
1,500	0	8	0	8	0	6	0	4	0	2	0	0	0	0	0	0
1,600	4	12	3	11	1	9	0	7	0	1	0	0	0	0	0	0
3,000	5	21	4	20	0	16	0	12	0	8	0	4	0	0	0	0

TABLE IV-13. THE NUMBER OF KEARNY PUMPS REQUIRED TO DISTRIBUTE AIR IN A CONFIGURATION 3d SHELTER STORY AS A FUNCTION OF ZONAL VENTILATION REQUIREMENT, STORY SIZE, AND BASEMENT OR FIRST-FLOOR STORY

Spaces	Zonal Ventilation Requirement (cfm)															
	8		10		15		20		25		30		40		50	
	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base
50	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3
100	0	3	0	3	0	3	0	3	0	3	0	3	0	1	0	1
200	0	3	0	3	0	3	0	1	0	1	0	1	0	0	0	0
300	0	3	0	3	0	1	0	1	0	1	0	0	0	0	0	0
400	0	3	0	1	0	1	0	0	0	0	0	0	0	0	0	0
500	0	3	0	3	0	3	0	2	0	1	0	1	0	0	0	0
600	0	4	0	4	0	3	0	2	0	2	0	1	0	0	0	0
700	0	4	0	4	0	3	0	2	0	1	0	0	0	0	0	0
800	0	5	0	4	0	3	0	2	0	1	0	0	0	0	0	0
900	0	5	0	4	0	3	0	2	0	1	0	0	0	0	0	0
1,000	0	5	0	5	0	4	0	2	0	1	0	0	0	0	0	0
1,100	0	5	0	5	0	3	0	2	0	0	0	0	0	0	0	0
1,200	0	6	0	5	0	4	0	2	0	1	0	0	0	0	0	0
1,300	0	6	0	5	0	3	0	2	0	0	0	0	0	0	0	0
1,400	0	7	0	6	0	4	0	2	0	0	0	0	0	0	0	0
1,500	0	6	0	6	0	4	0	2	0	0	0	0	0	0	0	0
1,600	0	7	0	6	0	4	0	2	0	0	0	0	0	0	0	0
3,000	0	11	0	10	0	6	0	2	0	0	0	0	0	0	0	0

TABLE IV-14. THE NUMBER OF KEARNY PUMPS REQUIRED TO DISTRIBUTE AIR IN A CONFIGURATION 4 SHELTER STORY AS A FUNCTION OF ZONAL VENTILATION REQUIREMENT, STORY SIZE, AND BASEMENT OR FIRST-FLOOR STORY

Spaces	Zonal Ventilation Requirement (cfm)															
	8		10		15		20		25		30		40		50	
	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base
50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
100	0	2	0	2	0	2	0	2	0	2	0	2	0	1	0	1
200	0	3	0	3	0	3	0	2	0	2	0	2	0	1	0	1
300	0	3	0	3	0	3	0	2	0	2	0	2	0	1	0	0
400	0	4	0	3	0	3	0	2	0	2	0	1	0	0	0	0
500	0	3	0	3	0	3	0	2	0	1	0	1	0	0	0	0
600	0	4	0	4	0	3	0	2	0	2	0	1	0	0	0	0
700	0	4	0	4	0	3	0	2	0	1	0	0	0	0	0	0
800	0	5	0	4	0	3	0	2	0	1	0	0	0	0	0	0
900	0	5	0	4	0	3	0	2	0	1	0	0	0	0	0	0
1,000	0	5	0	5	0	4	0	2	0	1	0	0	0	0	0	0
1,100	0	5	0	5	0	3	0	2	0	0	0	0	0	0	0	0
1,200	0	6	0	5	0	4	0	2	0	0	0	0	0	0	0	0
1,300	0	6	0	5	0	3	0	2	0	0	0	0	0	0	0	0
1,400	0	7	0	6	0	4	0	2	0	0	0	0	0	0	0	0
1,500	0	6	0	6	0	4	0	2	0	0	0	0	0	0	0	0
1,600	0	7	0	6	0	4	0	2	0	0	0	0	0	0	0	0
3,000	0	11	0	10	0	6	0	2	0	0	0	0	0	0	0	0

TABLE IV-15. THE NUMBER OF KEARNY PUMPS REQUIRED TO DISTRIBUTE AIR IN A CONFIGURATION 5 SHELTER STORY AS A FUNCTION OF ZONAL VENTILATION REQUIREMENT, STORY SIZE, AND BASEMENT OR FIRST-FLOOR STORY

Spaces	Zonal Ventilation Requirement (cfm)															
	8		10		15		20		25		30		40		50	
	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base
50	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3
100	0	4	0	4	0	4	0	4	0	4	0	4	0	3	0	3
200	0	5	0	5	0	5	0	4	0	4	0	4	0	3	0	3
300	0	5	0	5	0	4	0	4	0	4	0	3	0	2	0	2
400	0	6	0	5	0	5	0	4	0	4	0	3	0	2	0	1
500	0	5	0	5	0	5	0	4	0	3	0	3	0	1	0	0
600	0	6	0	6	0	5	0	4	0	4	0	3	0	1	0	0
700	0	6	0	6	0	5	0	4	0	3	0	2	0	1	0	0
800	0	9	0	8	0	7	0	6	0	5	0	4	0	2	0	0
900	0	9	0	8	0	7	0	6	0	5	0	3	0	1	0	0
1,000	0	9	0	9	0	8	0	6	0	5	0	4	0	1	0	0
1,100	0	9	0	9	0	7	0	6	0	4	0	3	0	0	0	0
1,200	0	12	0	11	0	10	0	8	0	7	0	5	0	2	0	0
1,300	0	12	0	11	0	9	0	8	0	6	0	4	0	1	0	0
1,400	0	13	0	12	0	10	0	8	0	6	0	4	0	1	0	0
1,500	0	12	0	12	0	10	0	8	0	6	0	4	0	0	0	0
1,600	0	15	0	14	0	12	0	10	0	8	0	6	0	2	0	0
3,000	0	25	0	24	0	20	0	16	0	12	0	8	0	0	0	0

TABLE IV-16. THE NUMBER OF KEARNY PUMPS REQUIRED TO DISTRIBUTE AIR IN A CONFIGURATION 6 SHELTER STORY AS A FUNCTION OF ZONAL VENTILATION REQUIREMENT, STORY SIZE, AND BASEMENT OR FIRST-FLOOR STORY

Spaces	Zonal Ventilation Requirement (cfm)															
	8		10		15		20		25		30		40		50	
	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base	1st	Base
50	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3
100	0	2	0	2	0	2	0	2	0	2	0	2	0	1	0	1
200	0	3	0	3	0	3	0	2	0	2	0	2	0	1	0	1
300	0	4	0	4	0	3	0	3	0	3	0	2	0	1	0	1
400	0	5	0	4	0	4	0	3	0	3	0	2	0	1	0	0
500	0	5	0	5	0	5	0	4	0	3	0	3	0	1	0	0
600	0	6	0	6	0	5	0	4	0	4	0	3	0	1	0	0
700	0	7	0	7	0	6	0	5	0	4	0	3	0	1	0	0
800	0	8	0	7	0	6	0	5	0	4	0	3	0	1	0	0
900	0	9	0	8	0	7	0	6	0	5	0	3	0	1	0	0
1,000	0	10	0	10	0	9	0	7	0	6	0	5	0	2	0	0
1,100	0	11	0	11	0	9	0	8	0	6	0	5	0	2	0	0
1,200	0	12	0	11	0	10	0	8	0	7	0	5	0	2	0	0
1,300	0	13	0	12	0	10	0	9	0	7	0	5	0	2	0	0
1,400	0	14	0	13	0	11	0	9	0	7	0	5	0	2	0	0
1,500	0	15	0	15	0	13	0	11	0	9	0	7	0	3	0	0
1,600	0	16	0	15	0	13	0	11	0	9	0	7	0	3	0	0
3,000	0	30	0	29	0	25	0	21	0	17	0	13	0	5	0	0

- Configuration 3d is partitioned as follows: 100 to 500 spaces, 5 rooms; 600 to 700 spaces, 6 rooms; 800 to 900 spaces, 7 rooms; 1,000 to 1,100 spaces, 8 rooms; 1,200 to 1,300 spaces, 9 rooms; 1,400 to 1,500 spaces, 10 rooms; 1,600 spaces, 11 rooms; and 3,000 spaces, 18 rooms.
- The hall in Configuration 4 contains 20 percent of the area of the story, and the remainder of the story is divided into rooms in the same manner as in Configuration 2.
- The large areas in Configuration 5 contain 50 percent of the area of the story, and the remainder of the story is divided into rooms in the same manner as in Configuration 2.
- Configuration 6 consists of 10 percent corridor, 20 percent large area, and 70 percent partitioned into rooms of comparable size as follows: 100 spaces, 2 rooms; 200 spaces, 3 rooms; 300 spaces, 4 rooms; 400 spaces, 5 rooms; 500 spaces, 6 rooms; etc., up to 3,000 spaces, 31 rooms.

In addition, it was implicitly assumed that the shelter stories within every size category, zonal ventilation requirement, and DCPA Region would follow the room configuration distribution exhibited in Table IV-1.

The numbers of Kearny pumps and PVKs required to ventilate the host-area shelters in each DCPA Region were calculated in accordance with the above guidelines and assumptions. Tables IV-17 through IV-24 present the Regional summaries. In every Region, significantly more PVKs are needed than Kearny pumps (ranging from 1.4 PVKs per Kearny pump in Region 1 to 25.4 PVKs per Kearny pump in Region 5). The reason for the relatively small requirement for Kearny pumps is the assumption that PVKs are placed to aid air distribution, particularly in shelters requiring multiple PVKs. Therefore, Region 5 has the lowest relative requirement for Kearny pumps because it contains zones with high ventilation requirements (thus requiring a large number of PVKs). It should also be noted (1) that large complex stories tend to need relatively fewer KPKs for distribution than do simpler configurations because the partitions aid in distributing the air and (2) that first-floor stories need

TABLE IV-17. REGION 1 SUMMARY OF HOST-AREA SHELTER PVK AND KPK REQUIREMENTS

Zonal Ventilation Requirement	8 cfm		10 cfm		15 cfm		Total	
Configuration	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs
1a	817	674	19,487	12,419	1,370	484	21,674	13,577
1b	232	189	5,408	3,225	380	127	6,020	3,541
1c	23	2	540	44	38	2	601	48
2	480	477	11,374	9,828	807	487	12,661	10,792
3a	209	137	4,867	2,740	342	87	5,418	2,964
3b	480	378	11,374	7,421	807	292	12,661	8,091
3c	23	11	540	347	38	6	601	364
3d	91	51	2,164	1,371	162	63	2,417	1,485
4	287	192	7,033	4,334	504	220	7,824	4,746
5	417	483	10,291	10,496	726	537	11,434	11,516
6	158	145	4,376	3,647	287	159	4,821	3,951
Total	3,217	2,739	77,454	55,872	5,461	2,464	86,132	61,075

TABLE IV-18. REGION 2 SUMMARY OF HOST-AREA SHELTER PVK AND KPK REQUIREMENTS

Zonal Ventilation Requirement	10 cfm		15 cfm		Total	
Configuration	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs
1a	4,668	2,663	9,519	2,794	14,187	5,457
1b	1,303	647	2,651	760	3,954	1,407
1c	132	10	273	16	405	26
2	2,733	1,964	5,543	3,012	8,276	4,976
3a	1,175	572	2,373	601	3,548	1,173
3b	2,733	1,456	5,543	1,736	8,276	3,192
3c	132	58	273	75	405	133
3d	524	290	1,053	391	1,577	681
4	1,696	902	3,440	1,295	5,136	2,197
5	2,470	2,161	5,027	3,257	7,497	5,418
6	1,010	678	2,151	1,105	3,161	1,783
Total	18,576	11,401	37,846	15,042	56,422	26,443



TABLE IV-19. REGION 3 SUMMARY OF HOST-AREA SHELTER PVK AND KPK REQUIREMENTS

Zonal Ventilation Requirement	15 cfm		20 cfm		25 cfm		30 cfm		Total	
	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs
Configuration										
1a	17,474	2,225	18,966	769	8,164	237	6,029	108	50,633	3,339
1b	4,867	560	5,270	200	2,261	58	1,717	26	14,115	844
1c	476	9	542	8	231	3	137	2	1,386	22
2	10,219	1,409	11,063	937	4,768	341	3,541	188	29,591	2,875
3a	4,365	420	4,753	176	1,481	47	1,496	24	12,095	667
3b	10,219	1,205	11,063	412	4,768	139	3,541	63	29,591	1,819
3c	476	225	542	14	231	5	137	2	1,386	246
3d	1,685	150	2,137	79	923	29	673	17	5,418	275
4	6,321	572	6,840	354	2,931	120	2,208	65	18,300	1,111
5	9,231	1,399	10,032	1,003	4,325	361	3,213	183	26,801	2,946
6	3,849	505	4,172	343	1,826	115	1,346	40	11,193	1,003
Total	69,182	8,679	75,380	4,295	31,909	1,455	24,038	718	200,509	15,147

TABLE IV-20. REGION 4 SUMMARY OF HOST-AREA SHELTER PVK AND KPK REQUIREMENTS

Zonal Ventilation Requirement	8 cfm		10 cfm		15 cfm		Total	
Configuration	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs
1a	4,068	2,986	31,543	17,411	5,785	1,621	41,396	22,018
1b	1,126	692	8,759	4,376	1,614	467	11,499	5,535
1c	116	8	881	59	164	9	1,161	76
2	2,379	2,178	18,409	14,537	3,375	1,989	24,163	18,704
3a	1,011	665	7,889	3,772	1,451	398	10,351	4,835
3b	2,379	1,590	18,409	9,852	3,375	1,077	24,163	12,519
3c	116	67	881	502	164	42	1,161	611
3d	459	317	3,505	2,024	674	258	4,638	2,599
4	1,461	958	11,391	6,458	2,086	853	14,938	8,269
5	2,150	2,290	16,656	15,607	3,049	2,132	21,855	20,029
6	883	768	7,014	5,259	1,301	733	9,198	6,760
Total	16,148	12,519	125,337	79,857	23,038	9,579	164,523	101,955

TABLE IV-21. REGION 5 SUMMARY OF MOST-AREA SHELTER PVK AND KPK REQUIREMENTS

Zonal Ventilation Requirement Configuration	8 cfm		10 cfm		15 cfm		20 cfm		25 cfm		30 cfm		40 cfm		50 cfm		Total	
	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs
1a	576	344	1,811	704	2,177	301	11,340	458	11,197	337	13,181	224	22,177	160	4,487	23	66,946	2,556
1b	153	51	505	134	607	54	3,113	141	3,114	70	3,639	46	6,136	47	1,265	8	18,532	551
1c	11	0	37	1	53	1	306	4	329	4	387	4	593	4	81	1	1,797	19
2	326	51	1,048	177	1,271	130	6,612	524	6,533	439	7,667	374	12,914	271	2,592	38	38,963	2,004
3a	145	63	458	26	519	39	2,804	73	2,793	58	3,248	44	5,540	42	1,149	7	16,656	352
3b	326	135	1,048	325	1,271	132	6,612	236	6,533	185	7,667	132	12,914	104	2,592	18	38,963	1,267
3c	11	0	37	1	53	1	306	6	329	6	387	6	593	4	81	1	1,797	25
3d	51	5	201	18	232	12	1,261	47	1,261	39	1,494	33	2,403	20	516	4	7,419	178
4	193	21	662	78	799	67	4,113	196	4,058	152	4,758	123	7,952	94	1,707	18	24,242	749
5	275	54	963	182	1,151	154	5,994	543	5,876	457	6,932	392	11,725	309	2,387	49	35,303	2,140
6	160	13	370	45	497	42	2,473	163	2,480	131	2,921	112	5,247	97	1,011	10	15,159	613
Total	2,227	737	7,140	1,691	8,630	933	44,934	2,391	44,503	1,878	52,281	1,490	88,194	1,152	17,868	182	265,777	10,454

TABLE IV-22. REGION 6 SUMMARY OF HOST-AREA SHELTER PVK AND KPK REQUIREMENTS

Zonal Ventilation Requirement	8 cfm		10 cfm		15 cfm		20 cfm		Total	
	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs
Configuration										
1a	4,404	3,580	2,863	1,725	9,757	3,054	169	24	17,193	8,383
1b	1,229	845	780	413	2,261	813	36	3	4,306	2,074
1c	126	6	85	3	264	9	2	0	477	18
2	2,577	2,535	1,665	1,426	5,716	3,434	62	33	10,020	7,428
3a	1,107	770	719	370	2,438	665	32	1	4,296	1,806
3b	2,577	1,809	1,665	929	5,716	1,726	76	9	10,034	4,473
3c	126	98	85	32	264	82	2	0	477	212
3d	496	343	313	186	1,096	405	10	1	1,915	935
4	1,591	1,071	1,028	602	3,536	1,384	42	11	6,197	3,063
5	2,327	2,529	1,508	1,443	5,163	3,608	68	37	9,066	7,617
6	969	924	642	490	2,154	1,232	75	15	3,840	2,661
Total	17,529	14,510	11,353	7,619	38,365	16,412	574	134	67,821	38,675

TABLE IV-23. REGION 7 SUMMARY OF HOST-AREA SHELTER PVK AND KPK REQUIREMENTS

Zonal Ventilation Requirement	8 cfm		10 cfm		15 cfm		20 cfm		Total	
	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs	PVKs	KPKs
Configuration										
1a	4,609	2,183	7,341	2,137	1,753	79	1,179	32	14,882	4,431
1b	1,287	378	2,048	440	493	21	332	8	4,160	847
1c	130	6	203	8	56	2	22	1	411	17
2	2,692	329	4,286	478	1,017	66	685	31	8,680	904
3a	1,158	435	1,831	401	437	17	281	7	3,797	860
3b	2,692	891	4,286	1,029	1,017	49	685	18	8,680	1,987
3c	130	8	203	12	56	2	22	1	411	23
3d	517	47	823	60	192	9	145	3	1,677	119
4	1,671	174	2,653	224	631	33	429	16	5,384	447
5	2,436	336	3,867	477	933	73	609	30	7,845	916
6	1,017	111	1,606	139	381	19	282	7	3,286	276
Total	18,339	4,898	29,147	5,405	6,966	370	4,671	154	59,123	10,827

TABLE IV-24. REGION 8 SUMMARY OF HOST-AREA SHELTER  
PVK AND KPK REQUIREMENTS

Zonal Ventilation Requirement	8 cfm	
	PVKs	KPKs
Configuration		
1a	5,358	4,015
1b	1,490	870
1c	150	4
2	3,125	1,626
3a	1,343	854
3b	3,125	1,911
3c	150	79
3d	598	222
4	1,938	658
5	2,826	1,572
6	1,156	587
Total	21,259	12 398

relatively fewer KPKs than do basements because of the availability of apertures.

The requirements for PVKs and Kearny pumps should be stated in terms of numbers needed per number of shelter spaces to be useful as a basis for making procurements. Therefore, the numbers of shelter spaces represented by the shelter stories that are presently in the host-area shelter inventory were estimated. This was accomplished by assuming that the average shelter story capacity in each range shown in Table IV-2 would be the midpoint of that range. For example, the average shelter story in the 201 to 300 space range would contain 250 shelter spaces. The number of host-area shelter spaces available in each DCPA Region was estimated by multiplying each average shelter story capacity by the number of shelter stories in that range, and the resulting figures were used to calculate the requirements for PVKs and Kearny pumps per 1,000 shelter spaces in each Region. Table IV-25 displays the results of these calculations.

The last two columns ("PVKs per 1,000 Shelter Spaces" and "KPKs per 1,000 Shelter Spaces") of Table IV-25 graphically illustrate the regional differences in ventilator requirements. The number of PVKs needed per 1,000 shelter spaces ranges from 3.5 in Region 3 to 9.2 in Region 5. The range in Kearny pump requirements is even greater--from 0.4 Kearny pumps per 1,000 shelter spaces in Region 5 to 3.1 Kearny pumps per 1,000 shelter spaces in Region 1. The greatest factor causing these differences is the zonal ventilation requirement, although the Kearny pump requirement is also greatly affected by the percentage of shelter stories in basements. It is important to recognize the regional differences in ventilator requirements when procurements are made, because the magnitudes of the differences are quite large.

TABLE IV-25. REGIONAL PVK AND KEARNY PUMP REQUIREMENTS  
PER 1,000 SHELTER SPACES

DCPA Region	PVKs	KPKs	Shelter Spaces*	PVKs per 1,000 Shelter Spaces	KPKs per 1,000 Shelter Spaces
1	86,132	61,075	19,166,125	4.5	3.2
2	56,422	26,443	10,582,000	5.3	2.5
3	200,509	15,147	29,072,050	6.9	0.5
4	164,523	101,955	34,820,725	4.7	2.9
5	265,777	10,454	28,765,825	9.2	0.4
6	67,821	38,675	14,083,150	4.8	2.7
7	59,123	10,827	13,077,625	4.5	0.8
8	21,259	12,398	6,084,275	3.5	2.0

\*Assumed average story size for each range of story sizes shown in Table IV-2 would be the midpoint of the range.



## V. EVALUATION OF DISTRIBUTION SYSTEMS FOR FALLOUT SHELTER SUPPLIES

One option for ensuring that supplies are available to host-area fallout shelters during a crisis situation is stockpiling. The Defense Logistics Agency (DLA) has evaluated the availability of warehouse space in Department of Defense facilities that are located in the proximity of risk areas. Warehouse storage space requirements were projected by risk area and state for water containers, commodes, and sanitation kits on the basis of the population to be sheltered in each host area. Projections were not made for ventilators because no methodology was available to DLA for determining numbers of ventilators needed. DLA found adequate space available in facilities such as National Guard Armories and Air Force Depots to make stockpiling feasible.

If shelter supplies are stockpiled, they will be stored on pallets, arranged by type of shelter supply. In the event that Crisis Relocation Plans are put into effect, the pallets will be shipped to the county seats of host-area counties. DLA has evaluated the logistics of distributing the pallets of supplies to host-area county seats. However, once the supplies have been delivered to the county seats, they still must be distributed to the individual fallout shelter facilities. This chapter contains an evaluation of alternative systems for distributing shelter supplies to individual host-area shelter facilities from the host-area county seat.

The Macon, Georgia, and Utica-Rome, New York, host areas were selected for use in the study of distribution systems. During a previous study [10], RTI surveyed host-area shelter facilities in most of the Macon host counties and Utica-Rome host townships. Information on shelter facility locations obtained during the field work permitted a more detailed analysis than would be possible in other host areas. Also, the range of shelter facility

characteristics found in these two host areas should be representative of conditions in the majority of host areas in the country. Shelter facilities in the Macon host area are much larger, on the average, than shelter facilities in the Utica-Rome host area. However, most shelter facilities in the Macon host area are located in, or very close to, the county seat. Shelter facilities in the Utica-Rome host area are at relatively much greater distances from the county seat. Therefore, these two host areas afford the opportunity to evaluate the effect of facility size and distance on the time required to distribute supplies to all of the shelter facilities in a host area. Appendix D contains listings of all shelter facilities, distances to the county courthouse, and required supplies for the Macon host-area by county and for the Utica-Rome host-area by township.

It originally was planned to evaluate the following three different methods of distribution:

- Deliver supplies directly from the county seat to the individual shelters.
- Deliver supplies from the county seat to towns close to the shelters, with people from each shelter picking up its allotment of supplies.
- People from each shelter pick up its allotment from the county seat.

However, after the locations of shelters in the Macon and Utica-Rome host areas were examined and after the tasks that would be involved in delivering supplies were identified, the decision was made only to evaluate different methods of delivering supplies directly from the county seat to the individual shelters. The other two methods of distribution were not directly addressed for the following reasons:

- The system with people from each shelter picking up its allotment from the county seat involves the same tasks as delivering supplies directly from the county seats to the individual shelters, except for the transportation from the shelter to the county seat. If the

assumption is made that the transportation occurs while the supplies are being delivered to the county seat from the warehouse, these methods of distribution require identical amounts of time.

- All of the shelters in the two host areas evaluated are located either in the county seat or in a town within 36 miles of the county seat. Adding an intermediate distribution point would greatly increase the material handling and clerical requirements (also introducing another step in which mistakes could be made) with little if any reduction in transportation requirements.

Basically, two different methods of delivering supplies directly from the county seat to the individual shelters were evaluated. One method would be to use a different truck to service each shelter facility (i.e., one truck per facility). Two different priority systems for determining the order in which to load the trucks were analyzed. These systems would include giving priority to trucks on the basis of size of shelter supplied (largest shelter first) and on the basis of the distance of the shelter from the county seat (greatest distance first). The other method that was evaluated would be to use one truck (or group of trucks) to deliver supplies to all of the shelters in a county or to one zone of a county (e.g., some counties were divided into quadrants). Hybrids of these methods were also evaluated in counties where the distribution of facilities around the county seat suggested variations. These hybrids will be discussed in subsequent paragraphs.

In order to identify the tasks involved in delivering supplies with a different truck serving each shelter facility, it was necessary to make the following assumptions:

- The supplies are delivered to the county courthouse from the warehouse on pallets, grouped by type of supply, and stacked in tiers of two pallets.
- One requisition for each shelter facility is available at the county courthouse.
- One person does the clerical work for all of the trucks.
- Loading and unloading are done by hand so that supplies can be broken down by individual shelter facility at the county courthouse.

- If less than a full case of water containers or commodes is required (the other types of supplies are packaged one to a case), someone other than the person loading the truck will open the case.
- One truck is loaded at a time.
- A sufficient number of trucks is available so that no truck is required to return to the county courthouse for a second load.

Based on these assumptions, the following tasks involved in delivering supplies directly from the county seat to the individual shelters were defined:

- Load truck (includes picking up container(s) from pallet and handstacking inside truck, but does not include walking between the two points).
- Walk between pallet and truck (assuming 40 feet each way between pallet and truck).
- Clerical activities (verification that materials shipped match requisition).
- Transportation (truck travelling at average speed of 25 mph).
- Unload truck (includes picking up container(s) inside truck and handstacking outside truck, but does not include walking between the two points).
- Walk between truck and shelter (assuming 20 feet each way between truck and position where containers are handstacked).
- Clerical activities (verification that materials received match requisition).

Standard material handling data [11] were used to estimate the time required to perform each of the above tasks. The times required for loading and unloading are functions of the weight of the load. It was assumed that one case of water containers (38 pounds), one case of commodes (30 pounds), two sanitation kits (34 pounds), one PVK (70 pounds), or one KPK (30 pounds) would be loaded or unloaded at a time. The times required for clerical activities are functions of the number of line items contained in the requisition. The average speed was assumed to be 25 mph because the driving would be in towns or on highways crowded with traffic transporting people and

supplies to the host-area shelter facilities. Table V-1 contains an example calculation of the amount of time required to deliver supplies from the Twiggs County Courthouse to the old Masonic Lodge (CRP Facility Number 3066C).

Twiggs County is located in the Macon Host Area.

In identifying the tasks involved in delivering supplies with one truck (or group of trucks) servicing all of the shelter facilities in a county or on one distribution route, the following assumptions were made:

- The supplies are delivered to the county courthouse from the warehouse on pallets, grouped by type of supply.
- Groups of requisitions (including one requisition summarizing the total supplies needed) for each distribution route are available at the county courthouse.
- One person does the clerical work for all of the distribution routes.
- One fork lift truck is used to load pallets of supplies for each distribution route.
- When less than a full pallet of supplies is needed, these supplies are hand loaded at the same time that pallets are being loaded by the fork lift truck.
- Trucks in adequate sizes and numbers are available so that no truck is required to return to the county courthouse for a second load.
- Unloading is done by hand; supplies are broken down by individual shelter facility at the shelter sites.

These assumptions were used to define the following tasks involved in delivering supplies with one truck (or group of trucks) to all of the shelter facilities in a county or on one distribution route:

- Set up (open doors and position bridge plate).
- Position forklift truck to pick up load on dock (first tier or second tier).
- Pick up; back away with load (20 feet).
- Transport load (20 feet) and return empty (40 feet).
- Set down load pallet.

Table V-1. Example Calculation of Time Required to Deliver  
Supplies to a Shelter Facility Using the One Truck per  
Shelter Facility Distribution Method\*

Task	Standard Time (min)	Task Time (min)
Load truck†		
2 water containers	0.116/2 wat. cont.	0.116
41 commodes	0.132/case + .096/comm.	0.624
4 sanitation kits	0.137/2 san. kits	0.274
2 PVKs	0.191/PVK	0.382
Walk between truck and pallet	0.348/load	3.480
Clerical activities	0.51/line item	2.040
Transportation	60/25 mi	19.680
Unload truck†		
2 water containers	0.205/2 wat. cont.	0.205
41 commodes	0.239/case + .175/comm.	1.131
4 sanitation kits	0.248/2 san. kits	0.496
2 PVKs	0.347/PVK	0.694
Walk between truck and shelter	0.174/load	1.740
Clerical activities	0.681/line item	2.724
TOTAL TIME		33.586

\*County: Twiggs County, Georgia  
CRP Facility Number: 3066C  
Facility Name: Old Masonic Lodge

†4 water containers per case, 10 commodes per case. Assume as much as 1 case of water containers, 1 case of commodes, 2 sanitation kits, 1 PVK, or 2 KPKs can be carried in one load.

- Clean up (remove bridge plate and close doors).
- Clerical activities (verification that materials shipped match requisition).
- Transportation (truck(s) traveling at average speed of 25 mph).
- Unload truck (includes picking up container(s) inside truck and handstacking outside truck but does not include walking between the two points).
- Walk between truck and shelter (assuming 20 feet each way between truck and position where containers are handstacked).
- Clerical activities (verification that materials received match requisition).

Standard material handling data also were used to estimate the time required for each of these tasks. The set-up and clean-up times were included because it was assumed that large trucks such as moving vans would be used to transport supplies under this option. The same rationale was used in estimating the times for clerical activities, transportation, and unloading as was used under the one truck per shelter facility distribution method.

Each method of delivering supplies from the county seat to the individual shelters was evaluated for each county in the Macon host area and for groups of townships in the Utica-Rome host area. The Macon host area is composed of the following nine counties: Houston, Twiggs, Peach, Baldwin, Bleckley, Dodge, Laurens, Monroe, and Pulaski. The Utica-Rome host area is contained entirely in Oneida County. Oneida County is divided into townships, which for the sake of the analysis of distribution methods were divided into five groups. Each group of townships lies along a direct route that could be followed by a truck(s) coming from the county courthouse in Utica. These groups of townships include:

- Annsville, Ava, Camden, Florence, Verona, Vienna
- Booneville, Lee

- Forestport, Remsen, Trenton
- Augusta, Bridgewater, Marshall, Paris, Sangerfield
- Vernon.

Table V-2 contains a summary of the total time required to supply all of the shelter facilities in each Macon host area county and in each group of townships in the Utica-Rome host area. The distribution method in which one truck per shelter facility would be loaded on the basis of the greatest distance first priority was not evaluated for Houston or Peach County, Georgia because all of the shelter facilities in these counties are located within the county seats, and specific locations could not be identified. It was assumed that the facilities are distributed at equal distances from each other about the city limits in evaluating the other two distribution methods. The one truck (or group of trucks) supplies all shelter facilities method was not evaluated for Bleckley or Monroe Counties because all of the shelter facilities are located in the county seats of these counties, within 1.2 miles of the county courthouse in Bleckley County and within 2.3 miles of the county courthouse in Monroe county. This same type of situation is evaluated for Houston, Peach, and Pulaski counties. In evaluating the one truck (or group of trucks) supplies all shelter facilities method, Twiggs and Dodge Counties were divided into quadrants (creating 4 different routes within each county). This was done because of the distribution of shelter facilities within these counties. Because of the large numbers of shelter facilities in Baldwin and Laurens Counties (resulting in large time requirements for both priority systems under the one truck per shelter facility method), a combination of the one truck per shelter facility is loaded on the basis of the largest facility first priority and the one truck (or group of trucks) supplies all shelter facilities methods was evaluated. In Baldwin County, three different routes



Table V-2. Total Time (Minutes) Required to Deliver Fallout Shelter Supplies Under Alternative Distribution Methods

Risk Area	Host County or Township(s)*	One Truck per Shelter Facility		One Truck (or Group of Trucks) Supplies all Shelter Facilities
		Largest Facility First Priority	Greatest Distance First Priority	
Macon, Georgia	Houston	977.7	-----†	1,161.0
	Twiggs	299.8	288.0	228.0
	Peach	400.0	-----†	505.2
	Baldwin	4,708.1	4,789.1	2,333.7**
	Bleckley	460.3	461.2	-----††
	Dodge	503.6	503.5	552.4
	Laurens	2,334.5	2,376.5	1,511.2**
	Monroe	841.7	857.8	-----††
	Pulaski	565.0	570.1	668.9
	Annsville, Ava, Camden, Florence, Verona, Vienna	572.5	639.7	859.2
Utica-Rome, New York	Boonville, Lee	534.6	513.3	767.6
	Forestport, Rensen, Trenton	275.6	259.7	413.0
	Augusta, Bridgewater, Marshall, Paris, Sangerfield	600.7	614.1	827.7
	Vernon	516.2	513.1	682.9

\*The Macon, Georgia host area is composed of nine counties. The townships are grouped so that a direct route could be followed from the county courthouse in Utica through each township in a group.

†The one truck per shelter facility loaded on the basis of the greatest distance first priority was not evaluated for Houston and Peach counties because all of the shelter facilities in these counties are located within the county seats, and specific locations could not be identified. It was assumed that the facilities are distributed at equal distances from each other about the city limits.

\*\*A combination of the one truck per shelter facility loaded on the basis of the largest facility first priority and the one truck (or group of trucks) supplies all shelter facilities methods was evaluated in Baldwin and Laurens Counties. In Baldwin county, three different routes were defined outside of the county seat city limits and one truck was assigned per facility inside the county seat city limits. The same approach was used for Laurens county with the exception that shelter facilities located outside the county seat city limits were grouped in quadrants.

††The one truck (or group of trucks) supplies all shelter facilities method was not evaluated for Bleckley or Monroe Counties because all of the shelter facilities are located in the county seats of these counties. This same type of situation was evaluated for Houston, Peach, and Pulaski Counties.

for trucks or groups of trucks were defined to clusters of shelter facilities outside of the county seat city limits and one truck per shelter facility was assigned inside the county seat city limits. This same approach was used for Laurens County with the exception that shelter facilities located outside of the county seat city limits were grouped in quadrants.

Once crisis relocation plans are put into effect during a crisis situation, it is critical that fallout shelters be upgraded and stocked with supplies as quickly as possible. Therefore, time is the criterion to be used in choosing a distribution system. An examination of Table V-2 shows that using one truck per shelter facility should almost always be faster than using one truck (or group of trucks) to supply all shelter facilities. Twiggs County is the lone exception (a hybrid system was evaluated in both Baldwin and Laurens Counties). In Twiggs County, there is a small number of shelter facilities (17), but they are scattered around the county in such a way that the county was divided into quadrants, so that four routes were identified. The combination of the small number of facilities and the reduced transportation time due to the four routes resulted in the one truck (or group of trucks) supplying all shelter facilities method being favored in this one case.

The largest facility first priority and the greatest distance first priority systems within the one truck per shelter facility method do not appear to differ significantly. However, loading trucks on the basis of the largest facility first priority results in more spaces being supplied in a shorter period of time. Furthermore, if trucks are loaded on the basis of the greatest distance first priority, the total distribution time will be increased if a relatively large shelter is located close to the county

courthouse. This is because the time required to unload the truck would be much greater than the transportation time (the transportation time associated with the greatest distance to a shelter facility in this sample, 35.8 miles, corresponds to the time required to unload the supplies for a shelter facility with about 5,000 spaces).

In general, the one truck per shelter facility loaded on the basis of the largest facility first priority method should be favored. It is a relatively easy method to implement, because records are kept on the number of shelter spaces in each facility. If there is a large number of shelters or shelter spaces, the total time required to deliver supplies could be reduced by increasing the number of trucks that is loaded at a time, however this would also decrease the reliability of the system. Although a hybrid system might appear to be needed in a county or township with a large number of shelters and shelter spaces, this would require a great deal more advance planning and would introduce more chances for error (e.g., some supplies would be loaded into trucks on pallets while others would be allocated to specific shelters at the county courthouse). Also, a loading dock, specialized material handling equipment, and skilled labor would be needed to load pallets of supplies. Hence, in a county or township with a large number of shelters or shelter spaces, it would probably be best to plan to use the one truck per shelter facility loaded on the basis of the largest facility first priority method and load several different trucks at a time.

## VI. CONCLUSIONS AND RECOMMENDATIONS

An objective of this study was the evaluation of the usefulness of data from the CRP Host Areas Facility Survey for planning ventilation systems in particular fallout shelters. It also was planned to use the survey data from the Macon, Georgia, and the Utica-Rome, New York, host areas to determine if six previously identified basic floor plans adequately describe the host-area shelter facilities. However, only exterior dimensions are required for the CRP Host Areas Facility Survey sketches. A review of the data revealed that none of the sketches from the Macon host area indicates interior partitions. In the sketches from Utica-Rome, load-bearing interior walls are indicated for 27 facilities, but all interior partitions are shown for only 7 facilities. Furthermore, exterior apertures are not identified on the sketches either. Therefore, the CRP Host Areas Facility Survey data are of limited usefulness in developing general or specific allocation and deployment plans.

On the basis of this finding, it is recommended that sketches made during the host-area survey should show as much detail as possible. Interior doorways, stairwells, and elevator shafts should be indicated, as well as interior partitions and apertures in exterior walls. Due to the complexity of the problem of defining a ventilation system for any facility with several rooms, multiple apertures, etc., it is recommended that this should not be done by surveyors in the field. The detailed sketches made in the field should be used by a ventilation expert to plan ventilation systems for each shelter. This will result in better designed ventilation systems and will require no further training of the surveyors.

Another objective of this study was to develop methods for determining the numbers of PVKs and KPKs required by a host area before it has been surveyed. Ratios of PVKs and KPKs required per 1,000 shelter spaces were

developed on a regional basis. These ratios display a great deal of regional variation, caused mostly by differences in zonal ventilation requirements, although the number of basements is also a factor that is Regional in nature. These large Regional differences in ventilator requirements must be recognized in making procurements and in identifying warehouse space before the procurements are made.

The evaluation of distribution systems for fallout shelter supplies indicates that, in delivering supplies from the county seat to individual shelter sites, one truck per shelter facility should be used. Although the total time required to supply all of the shelter facilities in a county is not significantly affected by the priority system used to load the trucks (largest facility first or greatest distance first), the largest-facility-first priority system is recommended. Because facility size (unloading time) has a greater impact than distance (transportation time) on the total distribution time, loading trucks in the order of largest facility first will always result in a total distribution time that is the minimum or not significantly greater than the minimum. It also results in the majority of the shelter spaces (those in the largest facilities) being supplied earlier than under the greatest-distance-first priority system. A further advantage is that information on facility size is already available for planning purposes.

Advance planning is essential if a distribution system for shelter supplies is to be successfully implemented during a crisis period. A bill of materials documenting the total quantities of supplies needed by each host county must be available at the warehouse as well as at the county seat of the host county. The county Civil Defense Director should prepare the bill of materials, using supply requisitions for each fallout shelter in his county to compile the total number of each type of supply needed. In addition to the

quantities of supplies needed, the bill of materials should include the name of the host county, the name of the county seat, the address of the county courthouse (the county courthouse was assumed to be the distribution point for the analysis herein), and the name and address of the warehouse where the supplies are stockpiled.

To facilitate the shipping of supplies from the warehouse to the county seats in the event of a crisis situation, the bill of materials should be used to break the supplies down into the number of cases needed by each county. The cases should be stored on pallets, arranged by type of supply and by destination (host county). Color-coded labels should be placed on each case, with the color indicating the destination. The name and address of the warehouse should be printed on the label.

Advance planning also should include arranging to have trucks available in the appropriate size and number to transport supplies from the county courthouse to the individual shelter facilities. If the trucks are located in the county seat and can be sent directly to the reception point, travel into the county seat from the shelter sites against the flow of traffic can be avoided.

At the reception point, people will be assigned to specific shelter facilities (assignments should be made on the basis of the largest-facility-first priority system), and shelter managers will be appointed. The shelter manager should receive plans for his shelter facility, including a requisition for supplies. This requisition will be a carbon copy of the requisition used by the county Civil Defense Director to prepare the bill of materials for the county. In addition to the required quantity of each type of supply, the requisition will include the shelter facility name, address and CRP Facility Number, and the address of the county courthouse.

The shelter manager must designate someone from the reception point to pick up the supplies at the county courthouse (e.g., the owner of the truck that is to transport supplies to the shelter facility). This person will receive the carbon copy of the requisition for supplies, which will give him the authority to receive the supplies at the county courthouse. The carbon copy can be matched with the original requisition at the county courthouse to assure that the correct quantity of supplies goes to each shelter.

If there is no attack, the supplies should be returned to the warehouse in which they were stockpiled for repair and restocking of materials. The color-coded label on each case upon which the identity of the warehouse is printed should facilitate this process.

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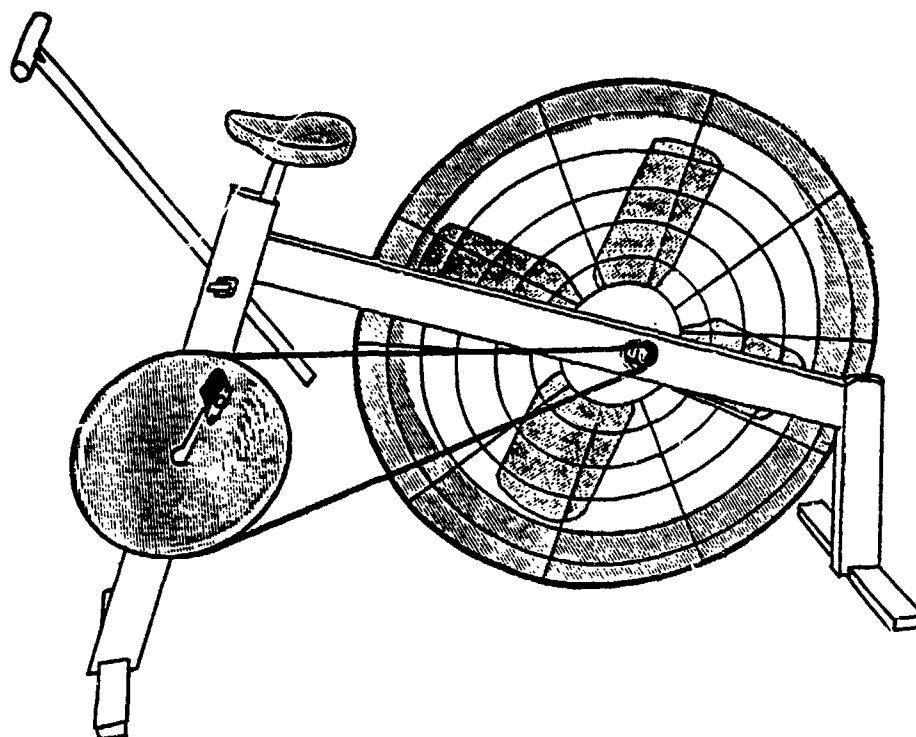
APPENDIX A

DESCRIPTION OF THE PACKAGE VENTILATION KIT AND THE  
KEARNY PUMP KIT

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KEARNY PUMP KIT

This appendix contains a description of the Package Ventilation Kit (PVK), including instructions for computing equivalent duct length and volume of air delivered as a function of equivalent duct length, and a description of the Kearny Pump Kit (KPK). A PVK generally should be used to supply fresh air (exhaust stale air) to a fallout shelter and could be placed to aid in air distribution. A KPK should be used to supply air to a small shelter (50 spaces or less) or to distribute air to stagnant areas within a shelter.

The PVK currently being considered by FEMA for use in ventilating fallout shelters was developed by the General American Research Division (GARD) and consists of a 30-inch axial fan and shroud that is operated manually with a pedal-crank and chain arrangement similar to a bicycle drive. Figure A-1 contains an illustration of a PVK. The specifications and performance characteristics of the PVK are described in a research report published by GARD [1]. In most shelter applications, it is necessary to use ducting attached to the fan in order to direct the air through the shelter along the proper path and to insure that stale air is exhausted from the shelter. The duct that is used with the PVK is 30 inches in diameter and is made from polyethylene plastic film. When the duct is attached to the fan, the capacity of the fan is lowered by varying amounts depending on the length of duct used and the number of bends in the duct. GARD performed evaluations of the ducting with different quantities of air moving through different lengths of duct to establish the pressure loss in the duct. By applying the curves developed from the duct evaluation to the curves of the PVK, a relationship



**Figure A-1. A 30-inch Packaged Ventilation Kit**

between fan capacity and duct length can be established. This relationship is shown in Figure A-2. Bends in the duct also reduces the air delivered by the PVK. This reduction is accounted for by determining length of straight duct that would cause a reduction in airflow (an increase in pressure) equivalent to the bend. These equivalent duct lengths (edl) have also been determined by GARD and are reported as follows:

- 45° bend, 50 ft
- 90° bend, 100 ft
- 120° bend, 150 ft.

To determine the amount of air delivered by a PVK in a particular application, the total equivalent duct length should be determined by adding the straight duct length and the equivalent duct length of any bends in the duct. The total equivalent duct length can then be used to determine the air delivery rate of the PVK from the graph in Figure A-2.

The KPK that is being considered for ventilating small shelters and for distributing air to stagnant areas within shelters was also developed by GARD. It consists of a rectangular frame within which are mounted a number of plastic, one-way flap valves. The frame is covered by a coarse wire mesh screen. The Kearny Pump can be mounted in a doorway and used to provide air to a small shelter or dead-end room or it can be mounted in an A-frame and used to distribute air. Air is moved unidirectionally by a Kearny Pump without the use of ducting. The Kearny Pump is manually swung by means of a rope attached to the pivot end. The flaps open as the pump swings away from the operator, and the flaps are closed during the power strike, as the operator pulls it towards him. The Kearny pump is composed of two, 3-foot-long flaps so that it can be installed as a 3-foot or a 6-foot Kearny Pump. Figure A-3 illustrates a 3-foot Kearny Pump mounted in a doorway, and Figure A-4 shows

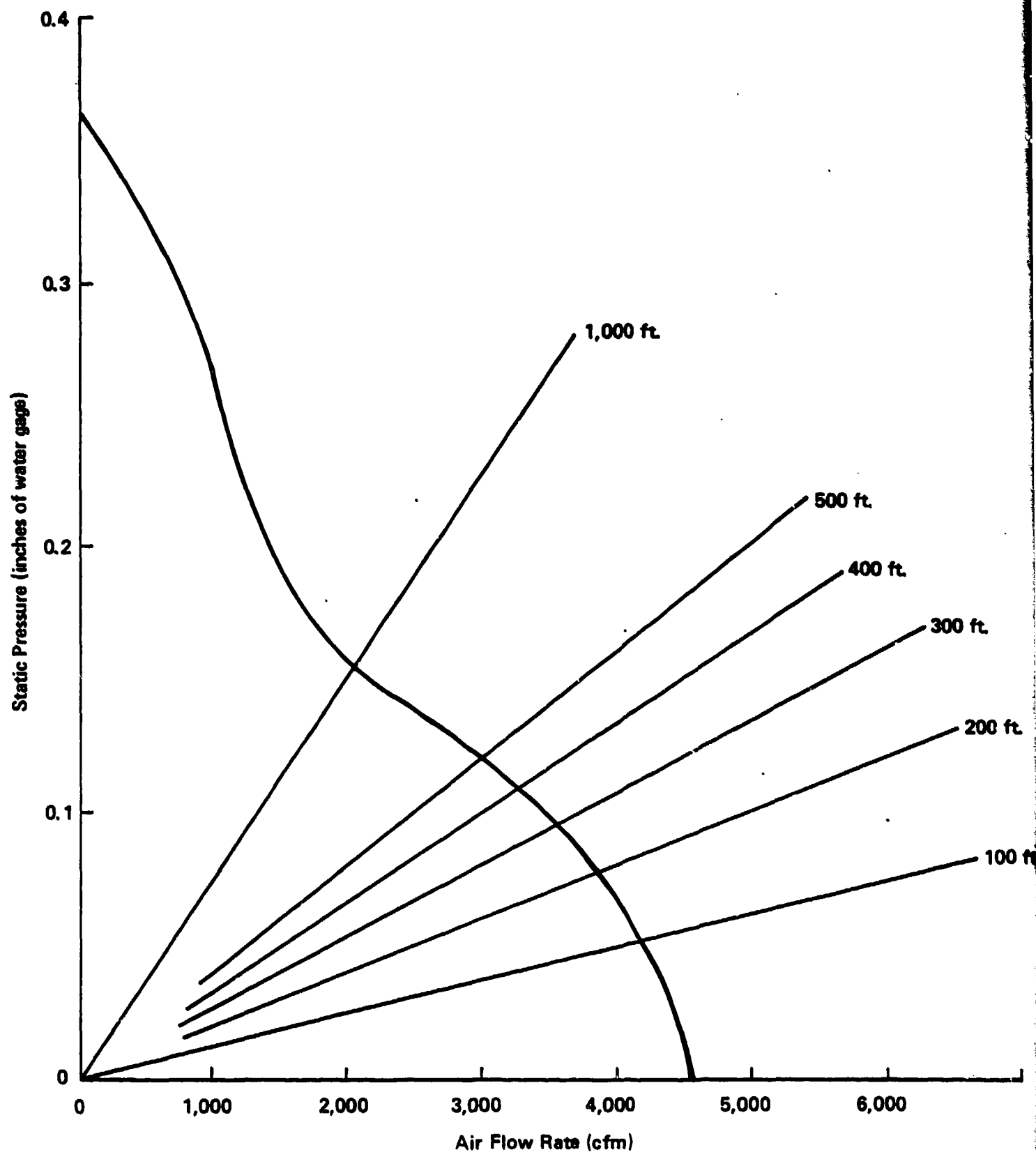


Figure A-2. PVK Performance and 30-inch Duct System Curves.

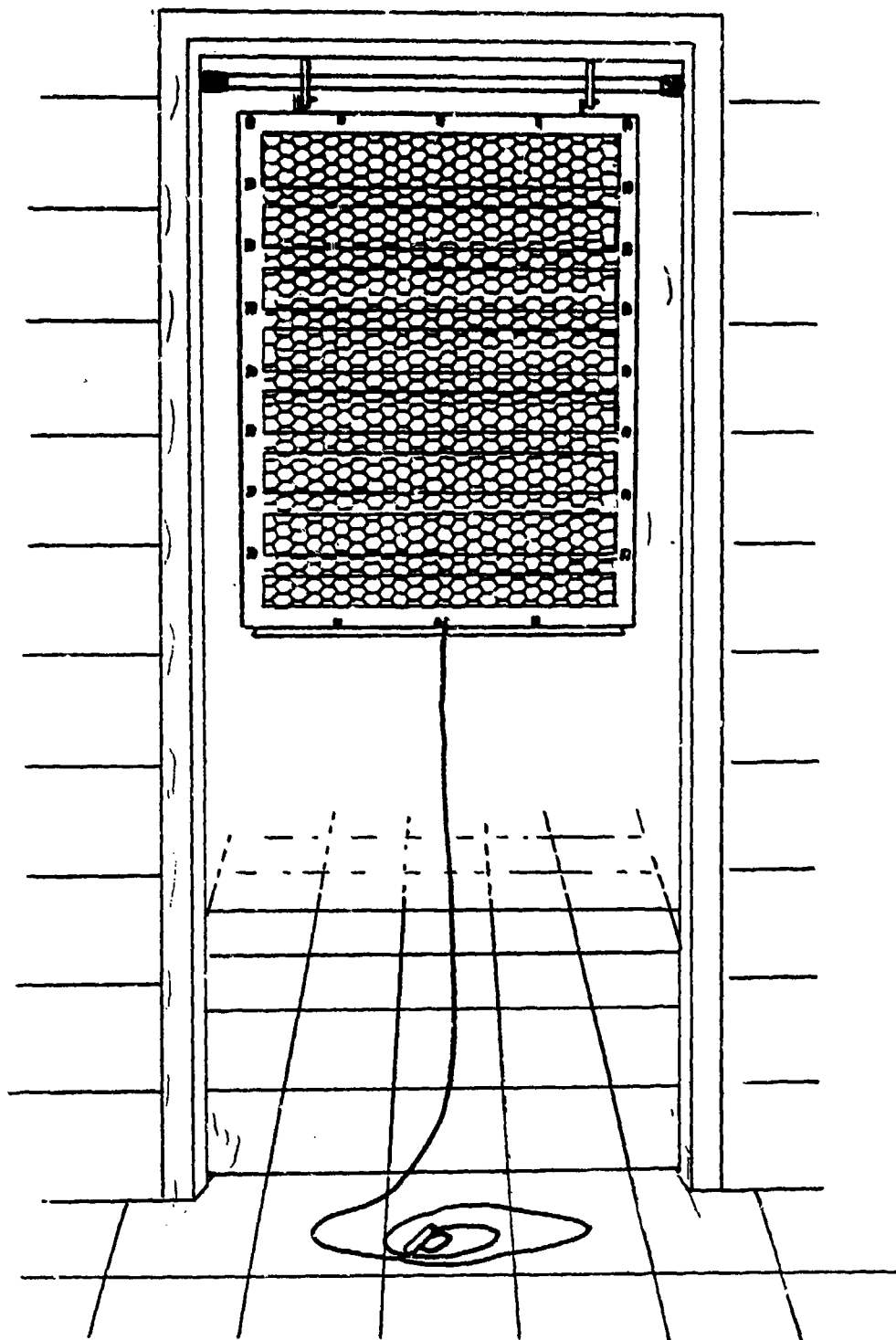


Figure A-3. A 3-foot Kearny Pump Mounted in a Doorway

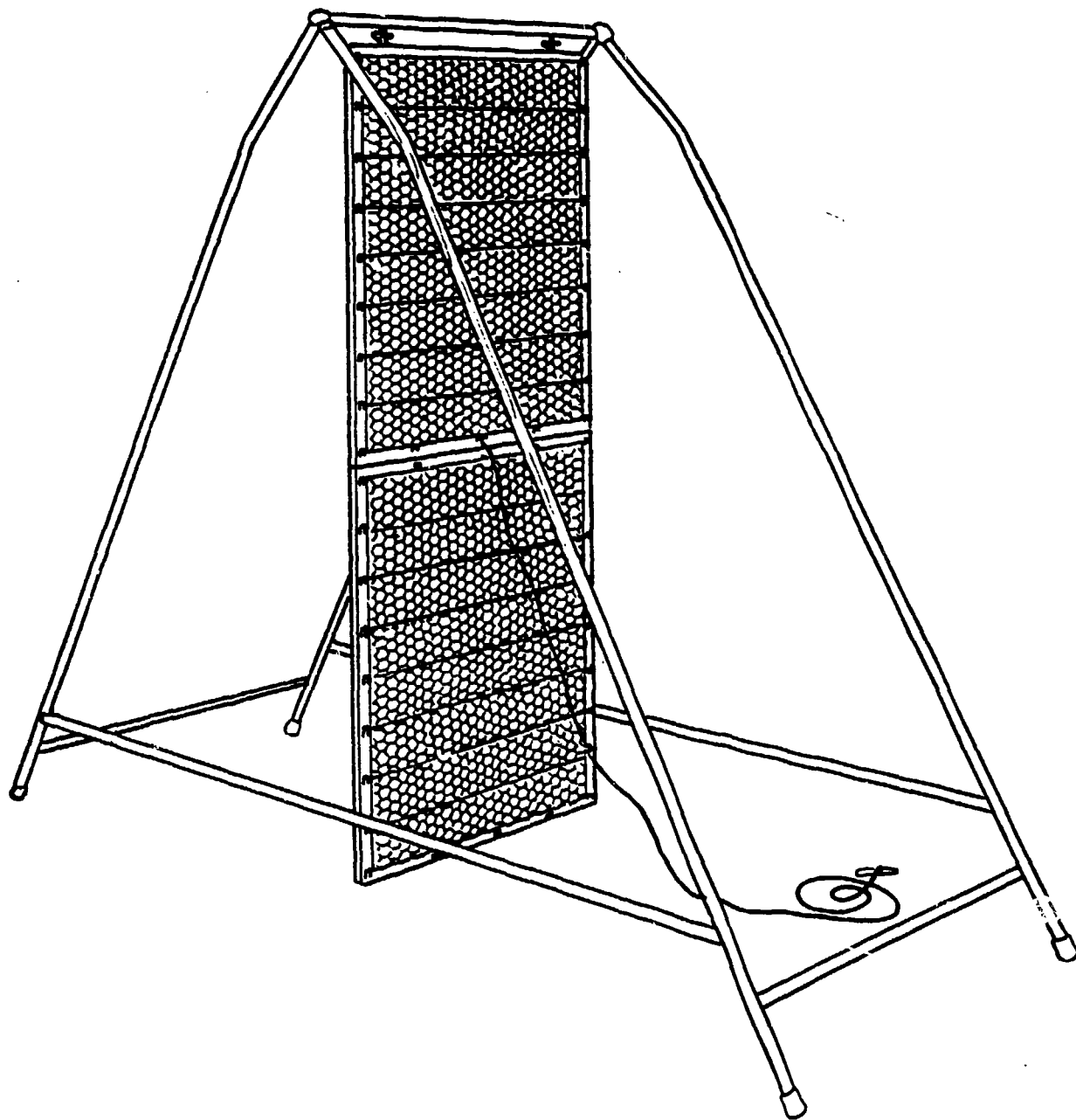


Figure A-4. A 6-foot Kearny Pump Mounted in an A-Frame

an A-frame support for a 6-foot Kearny Pump. Specifications for the KPK are described in the GARD report referenced earlier.

#### REFERENCES

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APPENDIX B  
EXAMPLE VENTILATION EQUIPMENT DEPLOYMENT PLANS

## APPENDIX B

### EXAMPLE VENTILATION EQUIPMENT DEPLOYMENT PLANS

Appendix B contains example ventilation equipment deployment plans that can be used as guidance in specifying deployment schemes for specific host-area shelters. For each code number (identified in Table I11-2) there are several examples illustrating the effects of shelter story size (a shelter story containing 50 or fewer spaces is referred to herein as a small shelter story) on equipment requirements and of aperture configuration on equipment deployment. When a ventilation plan is implemented based on the examples, it may be necessary to change the positioning of the ventilators if they are not working properly.

The symbol  is used to represent a PVK, with the arrow indicating the direction of air flow. The symbol  is used to identify a Kearny pump. Kearny pumps used to distribute air and to supply air to areas with only one aperture should be 3-foot Kearny pumps. A 6-foot Kearny pump should be used as the ventilator in a small shelter story unless there is only a single aperture to the outside.

#### I-A-1: Single Room Shelter with Multiple Apertures Per Wall in at Least Two Walls Directly Opposite Each Other

Figure B-1, part a, demonstrates the use of a Kearny pump in a small shelter story to exhaust air from an aperture in one wall while apertures in other walls serve as fresh air inlets. The shelters in Figure B-1, parts b and c, are large enough to require PVK(s) to exhaust air. Because the apertures are numerous and well distributed, only one ventilator is needed per 2,000 square feet of floor area for air distribution. Figure B-1, part c, illustrates the placement of the PVK to serve the dual purpose of exhausting stale air and distributing fresh air.

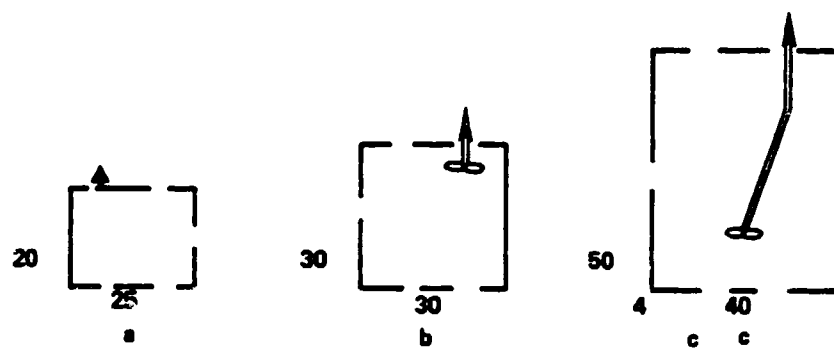


Figure B-1

I-A-2: Single Room Shelter with Single Apertures in Two Walls Directly Opposite Each Other

Figure B-2, part a, illustrates the positioning of a Kearny pump at the aperture on one side of the small shelter story to exhaust air and the use of the aperture on the opposite side to admit fresh air. Parts b and c of Figure B-2 show shelters that are large enough to require PVK(s) to exhaust air. One ventilator per 1,000 square feet of floor area is used to provide proper distribution of fresh air.

I-A-3: Single Room Shelter with Apertures in Two Adjacent Walls

Figure B-3, part a, displays the use of a Kearny pump to ventilate a small shelter story with apertures in two adjacent walls. Parts b and c of Figure B-3 present the locations of ventilation inlets and outlets and ventilators for exhausting stale air and distributing fresh air. The recommended numbers of ventilators are used for a shelter story with limited apertures.

I-A-4: Single Room Shelter with Multiple Apertures in Only One Wall

The ventilation of a small single room story with apertures in only one wall is best accomplished by using the Kearny pump to supply air to the room. Figure B-4, part a, illustrates this example of an exception to the general guideline of exhausting stale air from the shelter. Parts b and c of Figure B-4 show larger shelter stories in which one opening is used to exhaust air with the PVK(s) and the other(s) are used as fresh air inlets. The recommended number of ventilators is used.

I-A-5: Single Room Shelter with Only One Aperture in One Wall

Figure B-5, part a, shows the use of a Kearny pump to supply air (a maximum of 590 cfm) to a small shelter story with a single aperture. In a

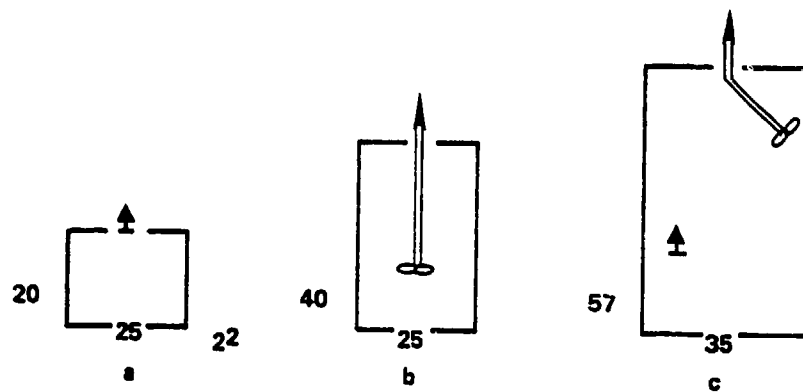


Figure B-2

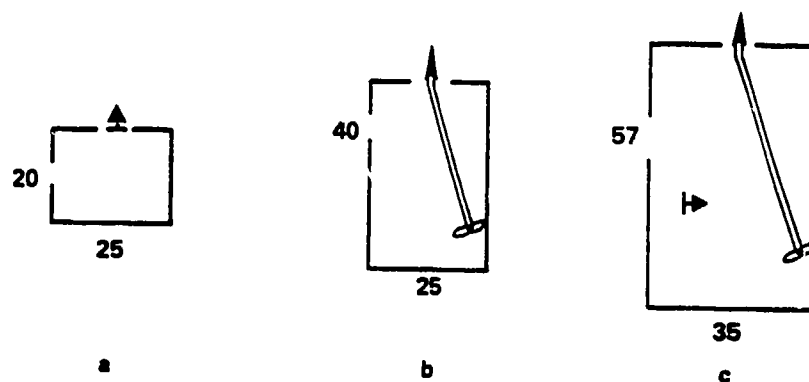


Figure B-3

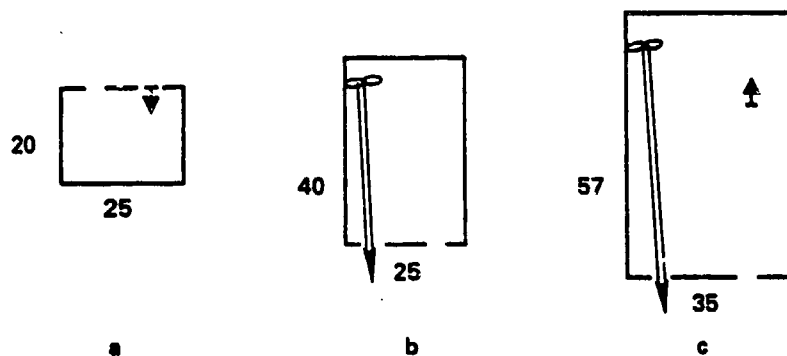
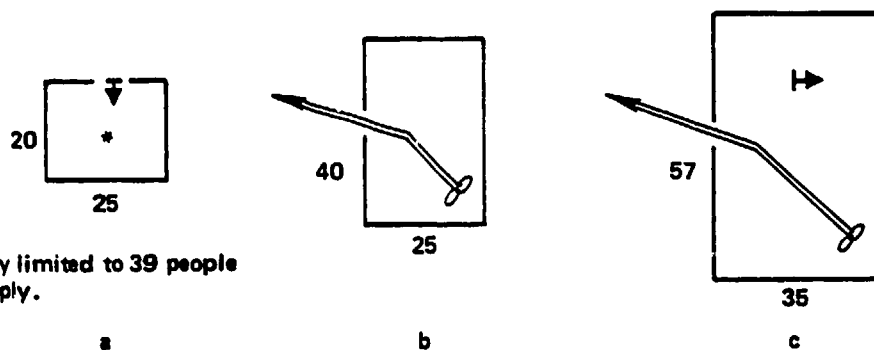


Figure B-4



\*Occupancy limited to 39 people  
by air supply.

Figure B-5

shelter story requiring PVK(s), the PVK(s) should be positioned in a remote corner and the duct passed out through the opening. The duct should extend far enough beyond the opening to prevent significant recirculation of stale air. The remaining portion of the opening allows fresh air to enter. Parts b and c of Figure B-5 show examples of ventilator deployment.

I-B-1a: Single Room with One Much Smaller Room (No Apertures in Small Room, Apertures in at Least Two Walls Directly Opposite Each Other in Large Room)

Figure B-6, part a, shows a Kearny pump exhausting air from a small shelter story with apertures in opposite walls and a small adjoining room with no apertures. If the small adjoining room is used as shelter, a Kearny pump must be placed in the connecting doorway to supply fresh air to the room. In larger shelter stories of this type, PVK(s) are used to exhaust air through the apertures in one side of the large room and the apertures on the opposite side serve as fresh air inlets. The small room is ventilated by placing a 3-foot Kearny pump in the doorway connecting the two rooms. Parts b and c of Figure B-6 illustrate the ventilator deployment for two different sizes of shelter. If the apertures serving as sources of supply air are located at one extreme end of the wall, the configuration is considered under Code I-B-1b.

I-B-1b: Single Room with One Much Smaller Room (No Apertures in Small Room, Single Apertures in Two Walls Directly Opposite Each Other in Large Room)

The deployment of the Kearny pump to ventilate a small shelter story of this configuration is identical to the deployment for a small shelter story of configuration I-B-1a (see Figure B-6, part a). In a larger shelter story, the opening in one wall is used to exhaust air with PVK(s) while the opening in the opposite wall allows fresh air to enter. Ventilators are allocated as recommended to mix the air in the large room and to supply air to the small

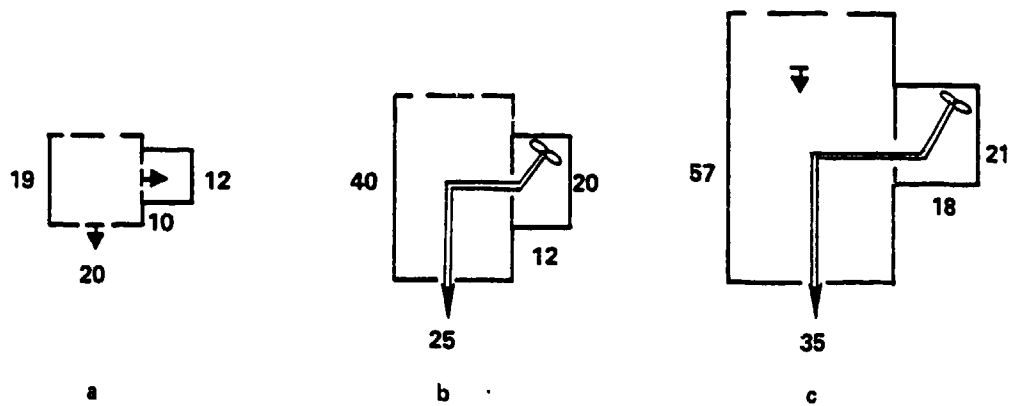


Figure B-6



room. Parts a and b of Figure B-7 illustrate the deployment of PVKs and Kearny pumps for this configuration.

I-B-1c: Single Room with One Much Smaller Room (No Apertures in Small Room, Apertures in Two Adjacent Walls of Large Room)

Figure B-8, part a, shows the use of a Kearny pump to ventilate a small shelter story of this configuration. The small adjoining room must be ventilated with 3-foot Kearny pump placed in the connecting doorway if it is to be used as shelter. A larger shelter story of this configuration is ventilated by using PVK(s) to exhaust stale air through the apertures in one wall while allowing fresh air to enter through the apertures in the other wall. Ventilators are allocated as recommended to obtain proper mixing in the large room, and a Kearny pump is installed in the doorway connecting the two rooms to provide ventilation to the small room. Parts b and c of Figure B-8 illustrate this system for two different sizes of shelter.

I-B-1d: Single Room with One Much Smaller Room (No Apertures in Small Room, Multiple Apertures in Only One Wall of Large Room)

Figure B-9, part a, shows the placement of a Kearny pump in one aperture to supply air to a small shelter story with multiple apertures in only one wall. This is an exception to the general guideline of using ventilators to exhaust stale air. The small room can be used only if a 3-foot Kearny pump is placed in the connecting doorway. In a larger shelter story, the PVK(s) are placed in a remote corner of the large room or in the small room if it is too large to be ventilated with a Kearny pump. The ducts are passed out through one of the apertures, and the remaining apertures are used as inlets. Ventilators are used in the numbers recommended to distribute air. Figure B-9, part b, illustrates a deployment plan for a shelter of this configuration in which the small room is small enough (requires a maximum of 590 cfm) to be

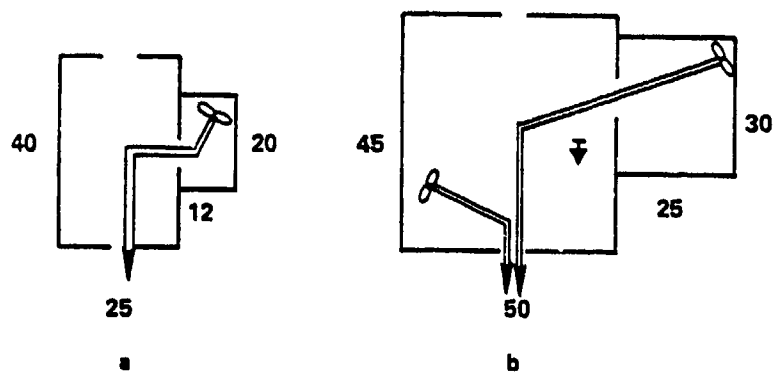


Figure B-7

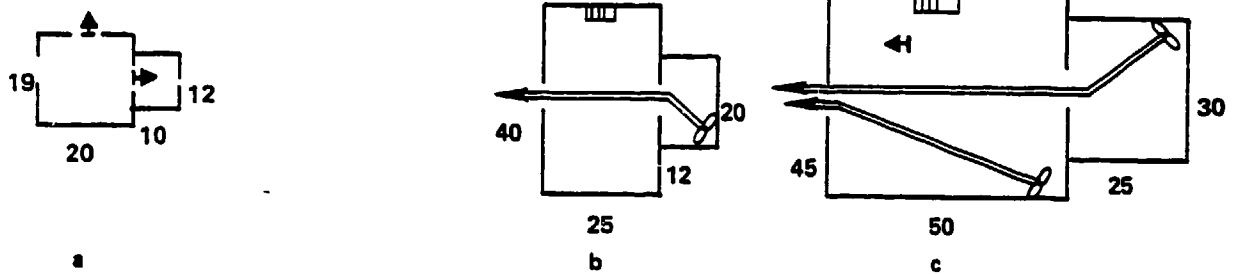


Figure B-8

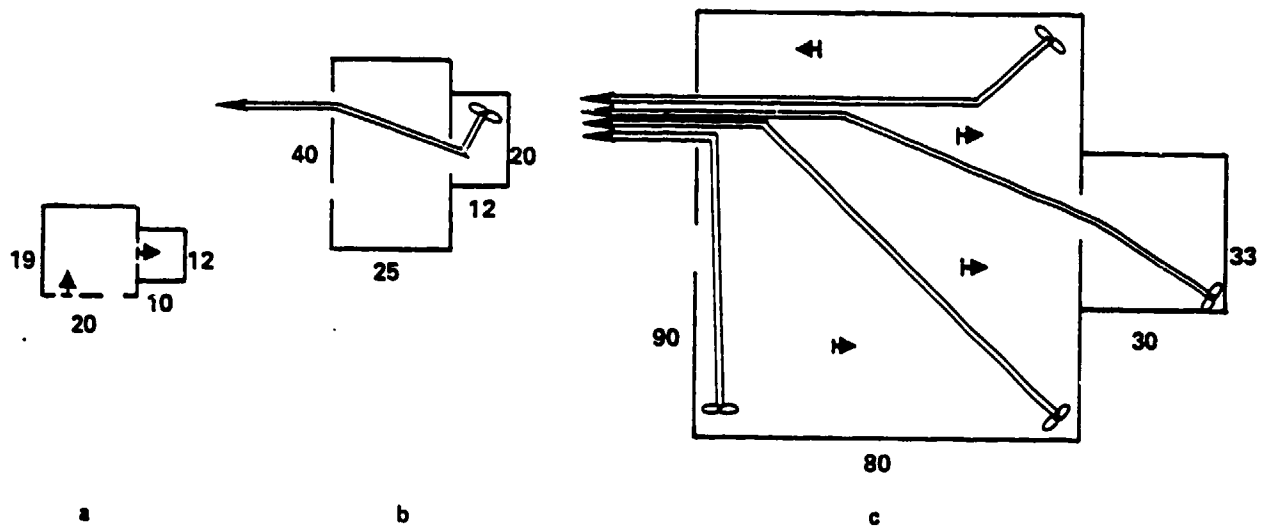


Figure B-9

ventilated with a Kearny pump. Figure B-9, part c, shows the PVK placement in the smaller room.

I-B-1e: Single Room with One Much Smaller Room (No Apertures in Smaller Room, Only One Aperture in One Wall of Large Room)

The single aperture must be used to supply and exhaust air. In a small shelter story (Figure B-10, part a), a Kearny pump may be placed in the aperture to supply air to the shelter. A 3-foot Kearny pump must be placed in the connecting doorway to supply air to the small room for it to be usable as shelter. For ventilating the larger shelter stories of this configuration, it is necessary to locate the PVK(s) in a remote corner of the large room or to locate them in the small room. If a PVK is not located in the small room, a Kearny pump is used to supply air to the small room. Parts b and c of Figure B-10 illustrate possible deployment plans for this type of shelter.

I-B-2a: Single Room with One Much Smaller Room (Apertures in Small Room, Apertures in the Wall of the Large Room Directly Opposite the Wall Adjoining the Small Room)

A small shelter story of this configuration can be ventilated with a Kearny pump that is used to exhaust air from the aperture in the large or the small room. Figure B-11, part a, illustrates this type of ventilation plan. PVK(s) are used in the same fashion in larger shelter stories with apertures in the small room and in the wall of the large room opposite the wall adjoining the small room. Parts b and c of Figure B-11 illustrate the deployment of ventilators in shelter stories in which there are no apertures in the large room other than in the wall directly opposite the adjoining wall. If apertures occur in more than one wall of both rooms, fewer ventilators are needed. Figure B-11, part d, illustrates this situation.

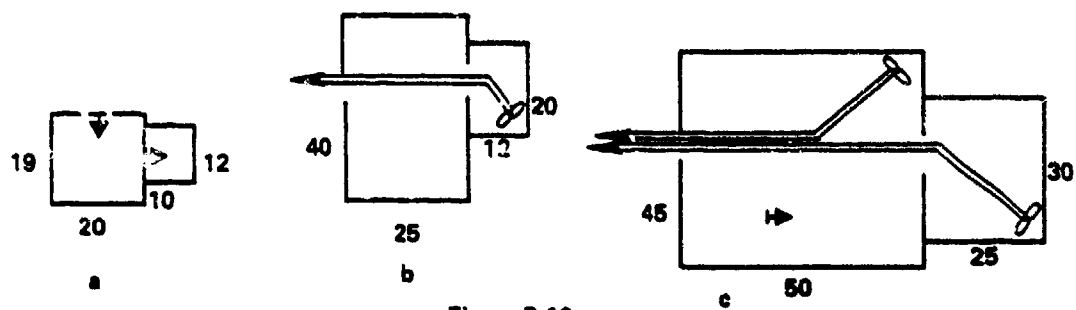


Figure B-10

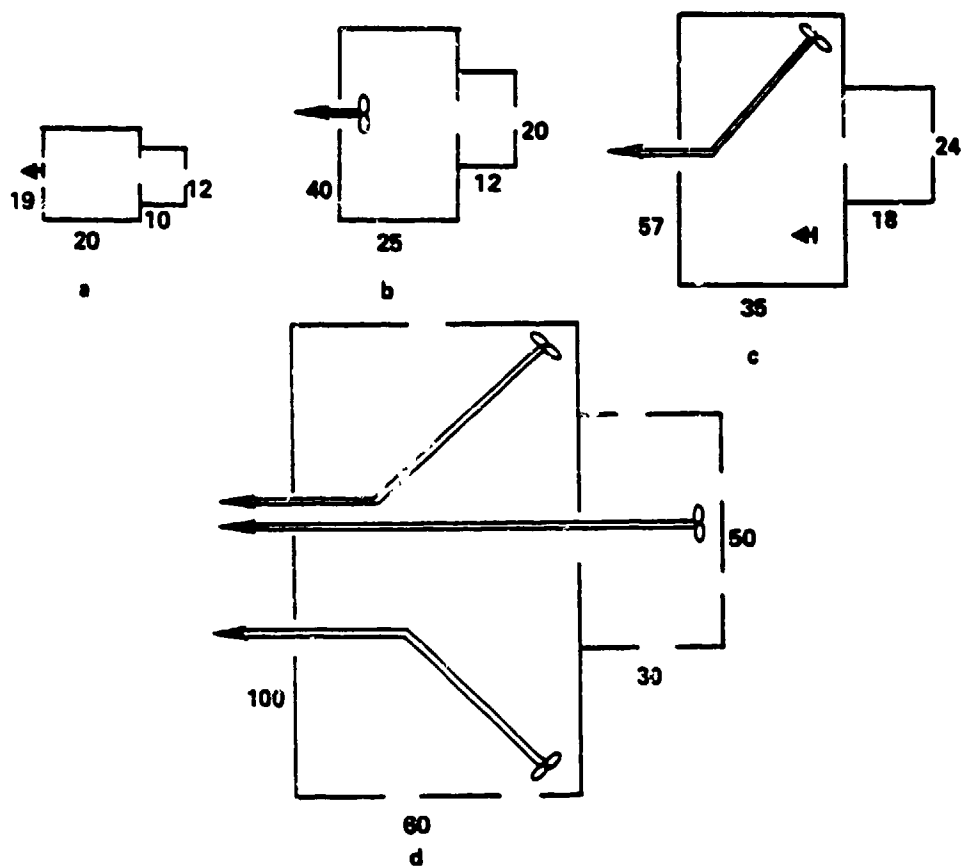


Figure B-11

I-B-2b: Single Room with One Much Smaller Room (Apertures in Small Room, Multiple Apertures Per Wall in Two Walls of Large Room Directly Opposite Each Other)

A Kearny pump can be placed in one of the apertures in the large room to exhaust air from a small shelter story of this configuration. Fresh air enters through the apertures in the opposite wall and through the apertures in the small room. Figure B-12, part a, illustrates this situation. Parts b and c of Figure B-13 show similar deployment plans that use PVK(s) in larger shelter stories.

I-B-2c: Single Room with One Much Smaller Room (Apertures in Small Room, Multiple Apertures in Only One Wall of Large Room)

In a small shelter story of the configuration, a single Kearny pump may be used exhaust air from the large room, with fresh air entering the apertures in the small room. Figure B-13, part a, shows this scheme. Similarly, parts b and c of Figure B-13 illustrate deployment plans in larger shelter stories that require PVK(s) to supply the air. Ventilators are allocated as recommended.

I-B-2d: Single Room with One Much Smaller Room (Apertures in Small Room, No Apertures in Large Room)

Figure B-14, part a, illustrates the use of a Kearny pump to ventilate a small shelter story of this configuration. In a larger shelter story requiring the use of PVK(s) to supply air, the PVK(s) can be placed in a remote corner of the large room and the duct(s) passed through the connecting doorway and out through the apertures in the small room. Ventilators are allocated as recommended for air distribution. Parts b and c of Figure B-14 present possible deployment plans for this configuration.

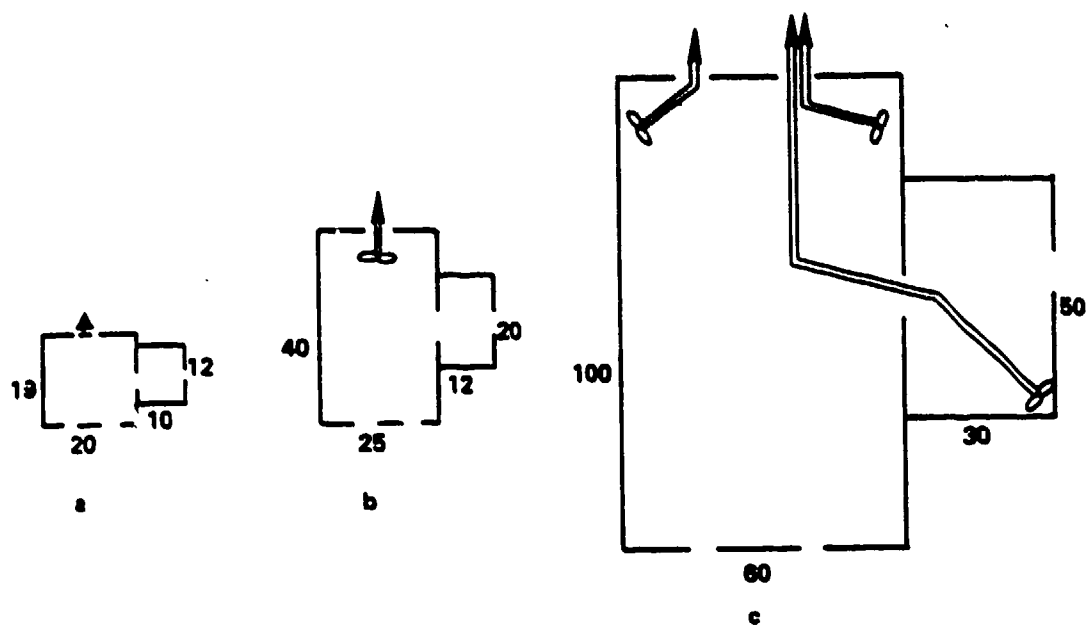


Figure B-12

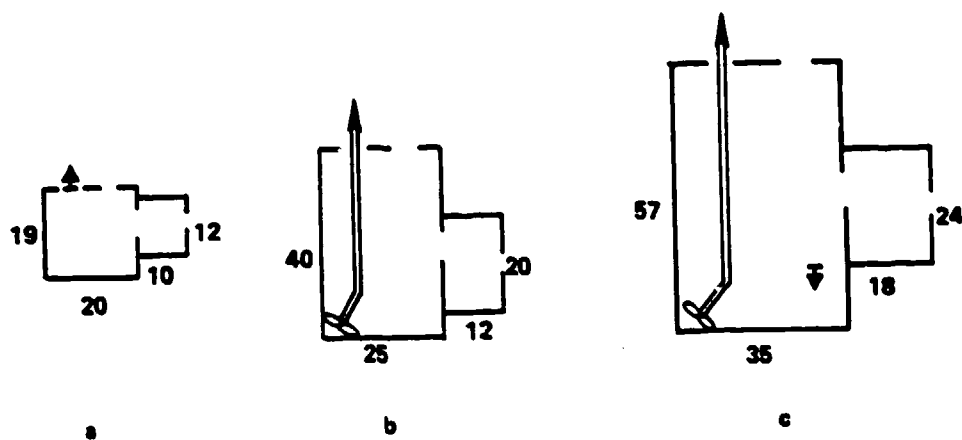


Figure B-13

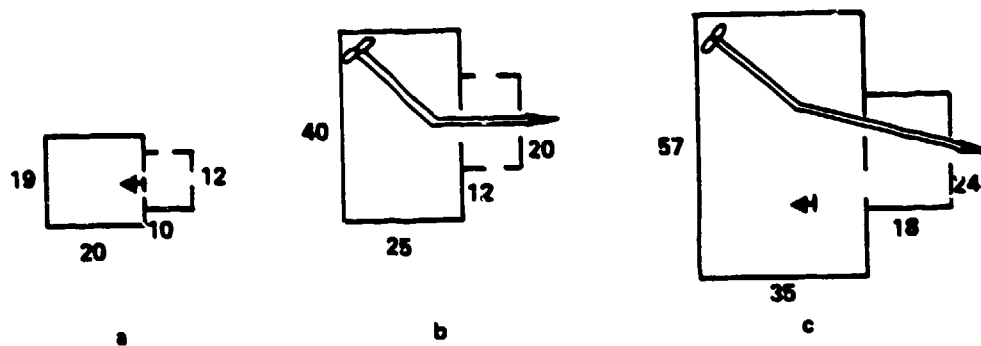


Figure B-14

**I-C-1: Winding Corridor with Apertures in or Near End of Corridor**

Figure B-15, part a, illustrates the placement of a Kearny pump to ventilate a small corridor with apertures at both ends. The placement of PVK(s) in a larger corridor (Figure B-15, part b) to exhaust stale air at one end and to allow fresh air to enter the other end is accomplished in the same manner.

**I-C-2: Winding Corridor with Apertures in or Near One End of Corridor and on at Least One Side**

In a small corridor of this configuration, a Kearny pump should be used to exhaust air from the side aperture. Figure B-16, part a, shows this arrangement. Inadequate ventilation may be a problem in the closed end of the corridor; however, in such a small shelter, the use of an additional Kearny pump is not practical. In a larger corridor, the PVK(s) are placed in the end with no aperture, and the duct passes through the aperture in the side wall of the corridor. Fresh air enters through the aperture at the end of the corridor. Figure B-16, part b, illustrates the PVK deployment for this configuration.

**I-C-3: Winding Corridor with Apertures in Side Walls of Corridor but Not Near the Ends**

Even a small corridor of this configuration cannot be effectively ventilated with one Kearny pump. Figure B-17, part a, shows a deployment scheme that is an inefficient utilization of Kearny pumps but that will ventilate both areas of the corridor. The best way to ventilate this type of corridor is to place PVKs in both ends of the corridor and to run the ducts out through one or more of the apertures. Figure B-17, part b, shows this type of deployment.

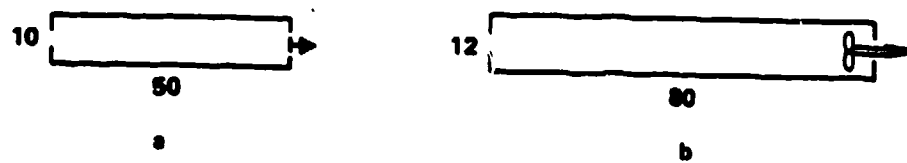


Figure B-15

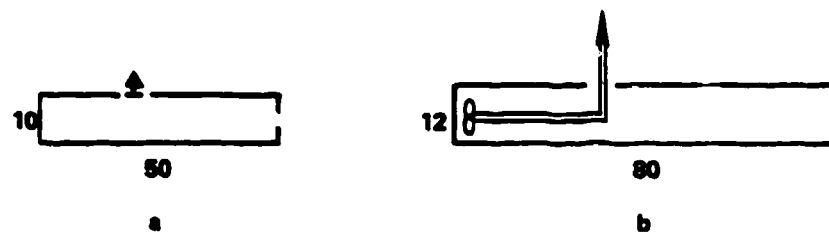


Figure B-16

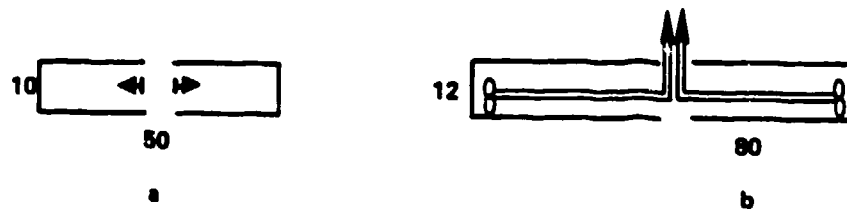


Figure B-17



**I-C-4: Winding Corridor with Apertures in or Near One End Only**

A small corridor of this configuration can be ventilated by placing a Kearny pump in the aperture to supply air (Figure B-18, part a). Figure B-18, part b, shows the placement of PVK(s) in the end with no apertures of a larger corridor. The duct(s) run the entire length of the corridor to the aperture.

**II-A-1: Large Area with Small Adjoining Rooms (Apertures in All Small Rooms and in Large Area)**

Figure B-19, part a, illustrates the use of a Kearny pump to exhaust air from the large room. Air enters through the apertures in the small rooms and those apertures in the large room not used for exhaust. Parts b and c of Figure B-19 show the use of PVKs to ventilate larger shelter stories of this configuration. If the apertures in the large and small rooms are numerous, Kearny pumps should not be needed for distribution.

**II-A-2: Large Room with Small Adjoining Rooms (Apertures in Large Area and Some of Small Rooms)**

In a small shelter story of this configuration (Figure B-20, part a), a Kearny pump can be used to exhaust air from the large area, with fresh air entering the apertures in the small room and the apertures in the large room not used for exhaust. The small windowless room cannot be used for shelter unless air is supplied to it with a Kearny pump. Parts b and c of Figure B-20 show larger shelter stories in which PVKs are used to exhaust stale air and to distribute fresh air and in which Kearny pumps are used to supply air to the dead-end rooms with no PVKs.

**II-A-3a: Large Area with Small Adjoining Rooms (No Apertures in Small Rooms, Apertures in Two Walls of Large Area Directly Opposite Each Other)**

Figure B-21, part a, illustrates the use of a Kearny pump to ventilate the large area in a small shelter story of this type. If the small rooms are

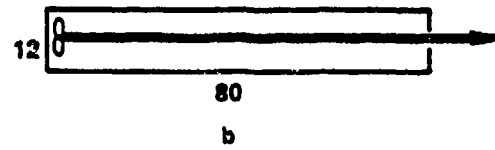
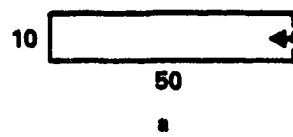


Figure B-18

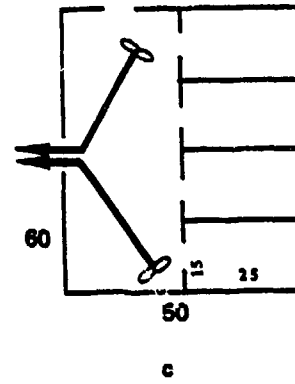
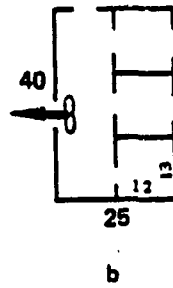
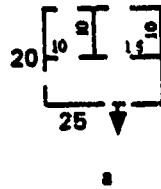


Figure B-19

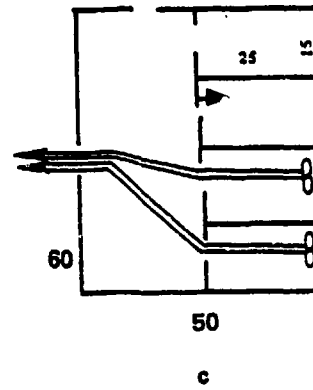
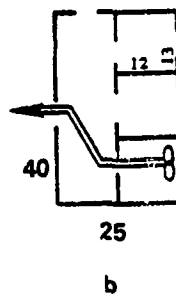
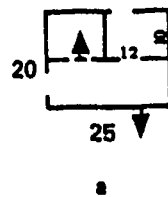
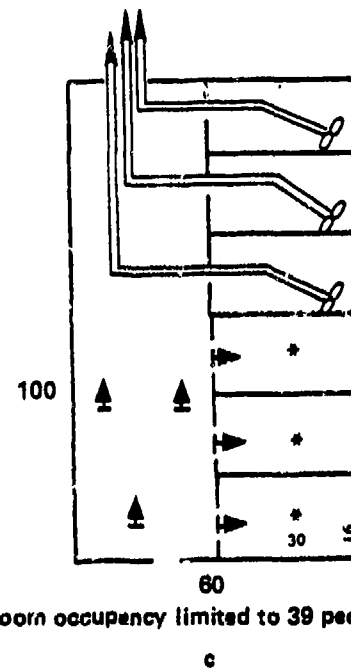
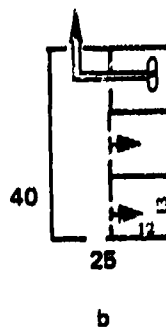
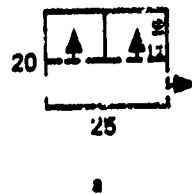


Figure B-20



\*Room occupancy limited to 39 people by air supply.

Figure B-21

to be usable, air must be supplied to each room by a 3-foot Kearny pump placed in the doorway. Parts b and c of figure B-21 show the deployment of PVKs and Kearny pumps to ventilate larger shelter stories of this configuration. The PVKs are used to exhaust air from the apertures in one wall, and air enters the apertures in the opposite wall. Kearny pumps are used to supply air to the dead-end rooms with no PVKs and to distribute air in the larger area.

**II-A-3b: Large Area with Small Adjoining Rooms (No Apertures in Small Rooms, Apertures in Two Adjacent Walls of Large Areas)**

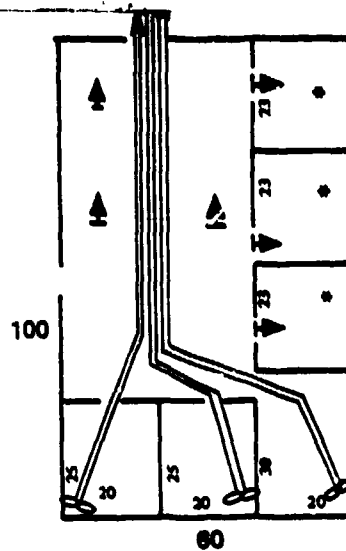
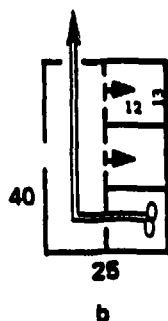
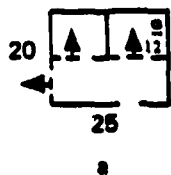
The configuration is ventilated in basically the same manner as Configuration II-A-3a. The apertures in one wall serve as fresh air inlets, while the apertures in the adjacent wall permit stale air to be exhausted. Figure B-22, part a, illustrates the use of Kearny pumps to ventilate a small shelter story of this type. Parts b and c of Figure B-22 show the deployment of PVKs and Kearny pumps in larger shelters of this configuration.

**II-A-3c: Large Area with Small Adjoining Rooms (No Apertures in Small Rooms, Multiple Apertures in Only One Wall of Large Area)**

In a small shelter story of this configuration (Figure B-23, part a), a Kearny pump is used to exhaust air from one of the apertures, and 3-foot Kearny pumps supply air to the small rooms if they are to be usable. Parts b and c of Figure B-23 illustrate the use of PVKs as exhaust systems for larger shelter stories of this configuration. The PVKs are placed in a remote corner of the large area or in a remote small room, and the ducts are passed through the apertures. In this scheme, ventilators are allocated as recommended for a shelter story with a limited number of apertures.

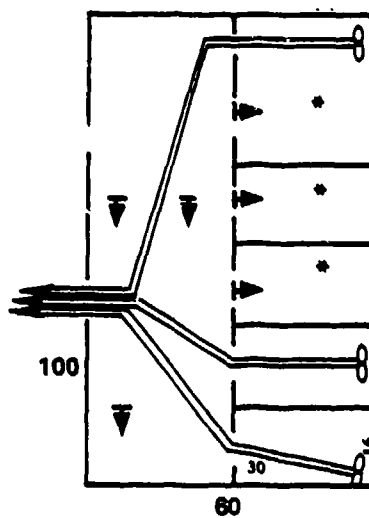
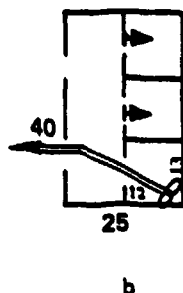
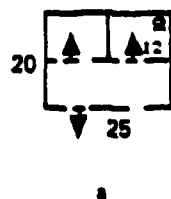
**II-A-3d: Large Area with Small Adjoining Rooms (No Apertures in Small Rooms, Single Aperture in One Wall of Large Area)**

In ventilating a small shelter story of this configuration (Figure B-24, part a), 3-foot Kearny pumps are used to supply air to the shelter (a maximum



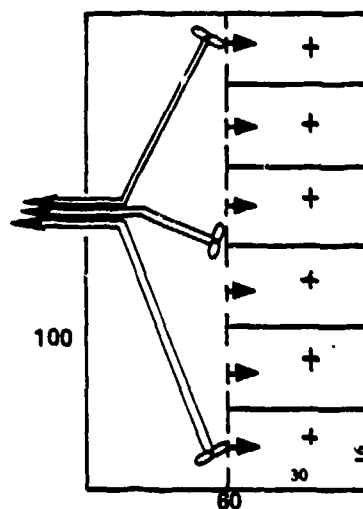
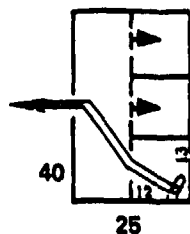
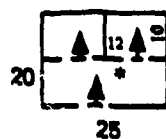
\*Room occupancy limited to 39 people by air supply.

Figure B-22



\*Room occupancy limited to 39 people by air supply

Figure B-23



\*Shelter story occupancy limited to 39 people by air supply.

Figure B-24

†Room occupancy limited to 39 people by air supply.

of 590 cfm) and to ventilate the adjoining rooms. In larger shelter stories requiring PVKs, the PVKs are located in a remote corner of the large area or in remote small rooms. The ducts are passed through the aperture and fresh air enters through the remaining portion of the aperture. The aperture size in combination with the ventilation requirements and effective duct length could limit the utilization of this type of shelter. Kearny pumps are used for mixing air in the large area and for ventilating the small rooms (maximum of 39 people can occupy a dead-end room ventilated with a Kearny pump). Parts b and c of Figure B-24 give illustrations.

II-A-4: Large Area with Small Adjoining Rooms (Apertures in All Small Rooms, None in Large Area)

Figure B-25, part a, illustrates the use of a Kearny pump to ventilate a small shelter story of this configuration. The method of ventilating a larger shelter story of this type depends on the location of the small rooms. If the small adjoining rooms occur on more than one side of the large area, PVK(s) used as exhaust blower(s) are placed in one or more of the small rooms, and fresh air enters through the remaining small rooms. If the large area is expansive enough to require ventilators for air distribution, it may be necessary to place the PVK(s) in the large area and to extend the duct(s) through the aperture(s) in the small rooms. If small rooms are on only one side of the large area, the PVK(s) should be located in a remote corner of the large area and the duct(s) passed through the apertures in a small room. The apertures in the remaining small rooms allow fresh air to enter. The allocation of ventilators for air distribution is dependent on the number and distribution of apertures. Parts b through e of Figure B-25 illustrate deployment plans for ventilating large shelter stories of this type.

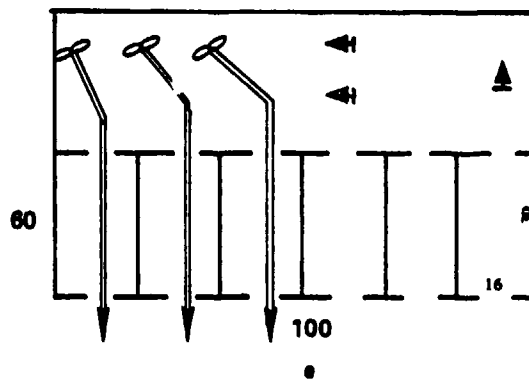
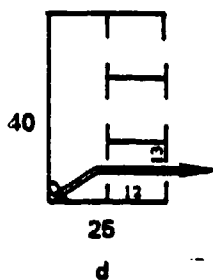
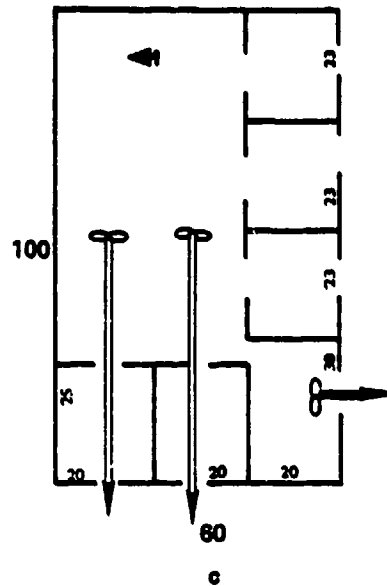
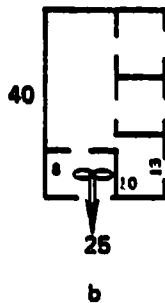
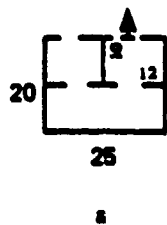


Figure B-25

II-A-5: Large Area with Small Adjoining Rooms (Apertures in Some Small Rooms, None in Large Area)

A Kearny pump should be used to supply air (a maximum of 590 cfm if there is only one aperture) to a small shelter story of this configuration. As part a of Figure B-26 illustrates, a 3-foot Kearny pump must be used to supply air to the small windowless room if it is to be used as shelter. In deploying PVKs to ventilate a larger shelter story of this type, the same considerations apply as in ventilating Configuration II-A-4 shelters. If this configuration has rooms on more than one side of the large area, and one or more rooms on each side of the large area have apertures, ventilation is provided by using PVK(s) as exhaust blower(s) in one or more small rooms and allowing fresh air to enter through the remaining small rooms. If the large area is expansive enough to require ventilators for air distribution, it may be necessary to place the PVK(s) in the large area and extend the duct(s) through the aperture(s) in the small rooms. If rooms occur on only one side of the large area, or if the rooms with apertures are all on the same side of the large area, the PVK(s) should be positioned in remote corner(s) of the large room and the duct(s) passed through the aperture(s) in one of the small rooms, allowing air to enter through the other small rooms. Kearny pumps are used as recommended to aid in air mixing and to ventilate small windowless rooms. Parts b through e of Figure B-26 illustrate ventilator deployment plans.

III-A-1: Partitioned into Two Rooms of Comparable Size (Apertures in Both Rooms in Walls Opposite Common Wall)

As illustrated in Figure B-27, part a, a Kearny pump is used to exhaust air through an aperture in one room with fresh air entering the apertures in the other room. The deployment plan is the same in larger shelter stories, with PVK(s) replacing Kearny pumps in exhausting stale air. The number of

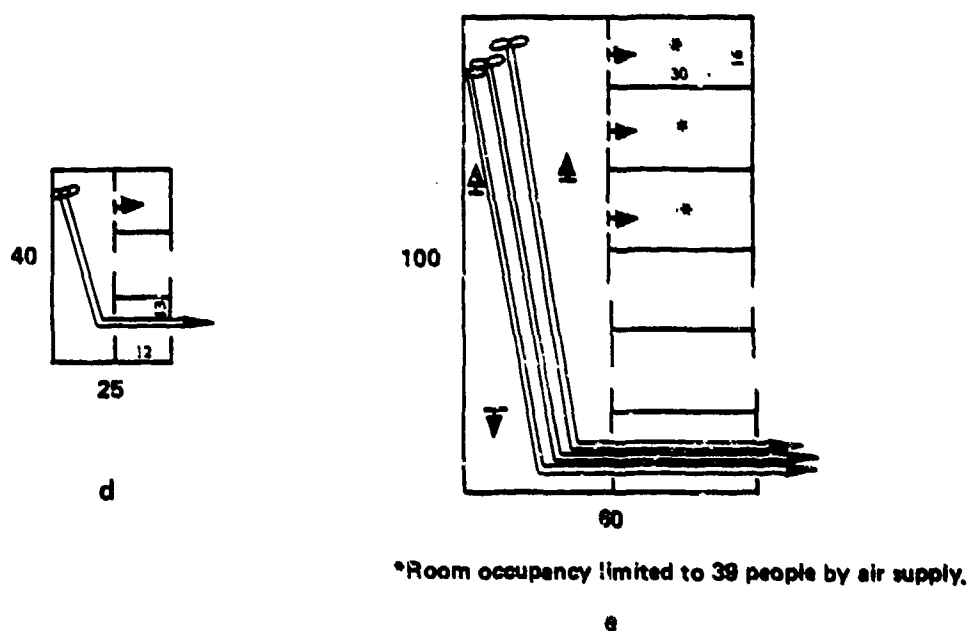
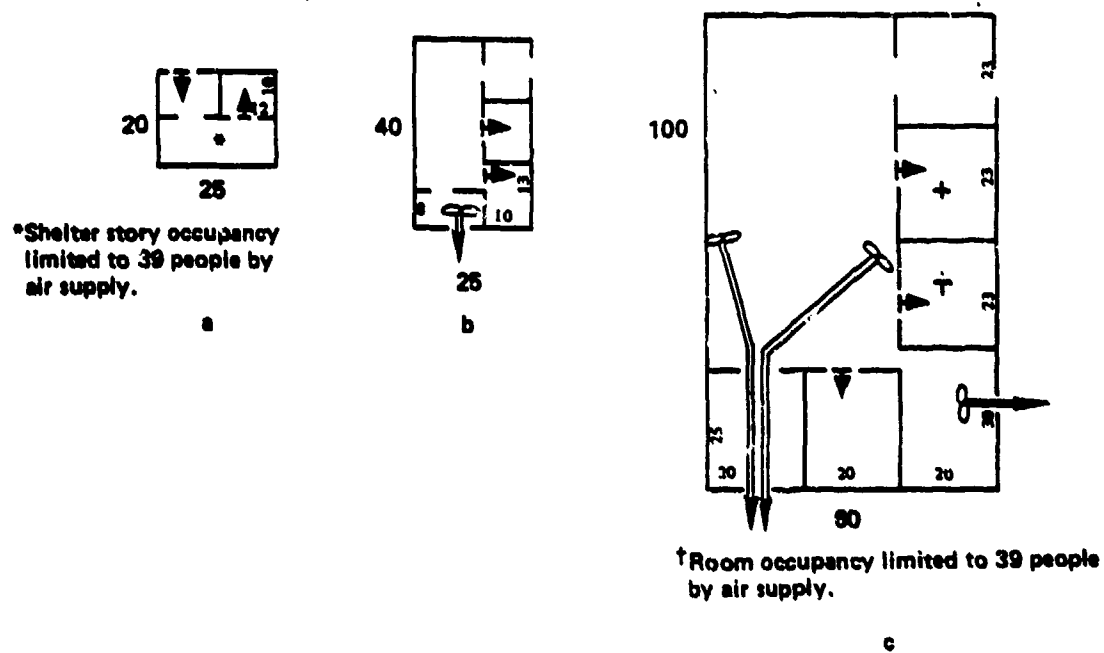
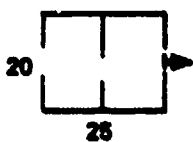
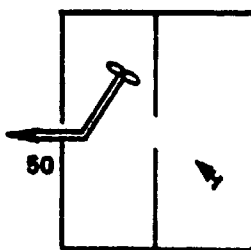


Figure B-26



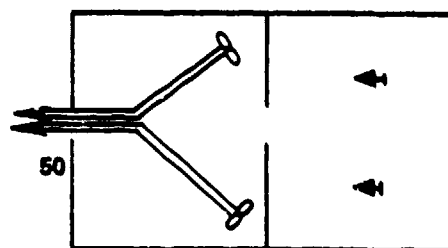


a



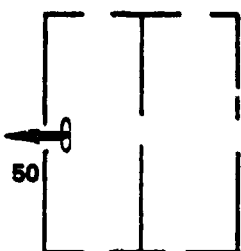
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b

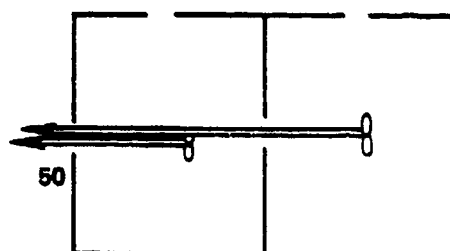


80

c



d



e

Figure B-27

ventilators required for air distribution is a function of the distribution of apertures in the walls opposite the common wall and in the other walls. Parts b and c of Figure B-27 illustrate cases where the apertures are not well distributed. In Figure B-27, parts d and e, fewer ventilators are needed because the apertures are well distributed.

III-A-2: Partitioned into Two Rooms of Comparable Size (Apertures in Both Rooms but Not in Walls Opposite Common Wall)

A Kearny pump is used to exhaust air from one aperture in a small shelter story of this configuration while the other apertures serve as fresh air inlets. Figure B-28, part a, illustrates this situation. The deployment plan for ventilating a larger shelter story of this type depends on the number and distribution of apertures. Parts b and c of Figure B-28 show ventilation plans for shelter stories in which several apertures exist in all walls other than those opposite the common wall. Distribution of fresh air should not be difficult to attain. At the other extreme, parts d and e of Figure B-28 illustrate cases where apertures are very limited in number or not adequately distributed. Fresh air enters in only one room so that more ventilators are needed for distribution.

III-A-3a: Partitioned into Two Rooms of Comparable Size (Apertures in One Room Only--Multiple Apertures in Two Walls Directly Opposite Each Other)

Figure B-29, part a, illustrates the positioning of the two Kearny pumps required to ventilate a small shelter story of this type. One Kearny pump should be used to exhaust air from an aperture while other openings serve as fresh air inlets. The second Kearny pump is used to supply air to the windowless room. In a larger shelter story of this type, PVK(s) are placed in a remote corner of the windowless room and the duct(s) are passed through

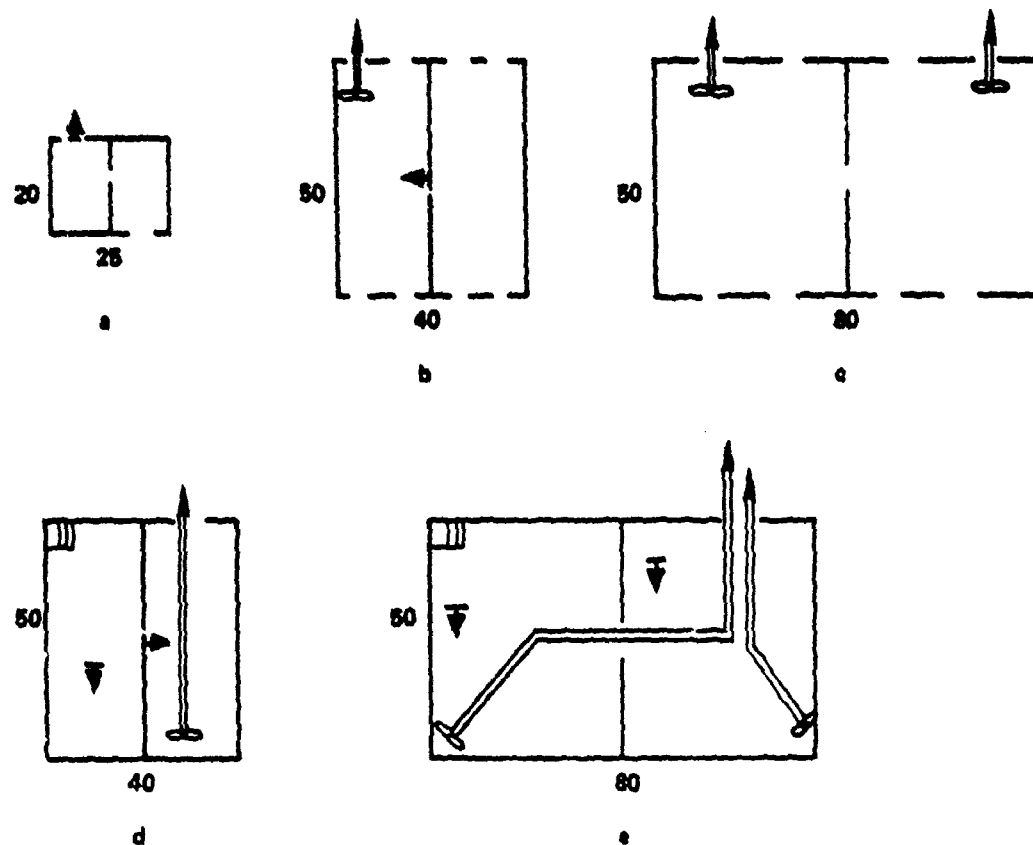


Figure B-28

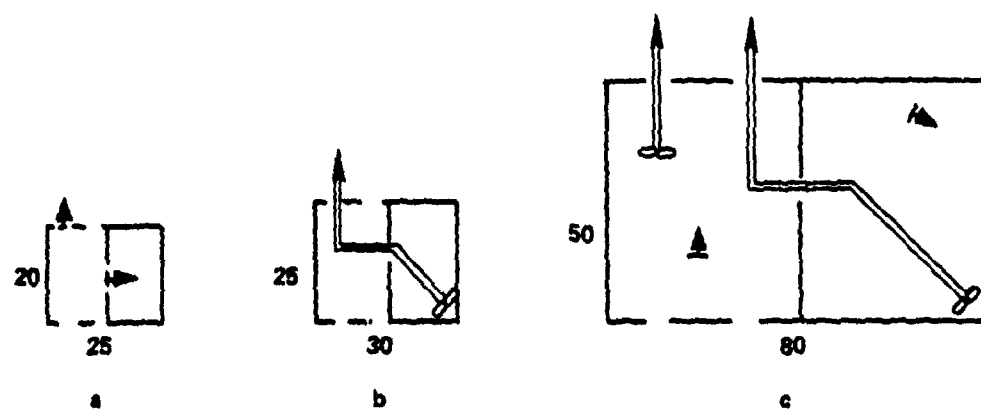


Figure B-29

the doorway connecting the two rooms and out through the aperture(s) in the other room. Ventilators are allocated as recommended to provide proper mixing in both rooms. Parts b and c of Figure B-29 illustrate deployment plans for this case.

**III-A-3b: Partitioned into Two rooms of Comparable Size (Apertures in One Room Only--Aperture in Two Adjacent Walls)**

Shelter stories of this configuration are ventilated in basically the same manner as Configuration III-A-3a shelter stories. Two Kearny pumps (Figure B-30, part a, illustrates deployment) are needed in small shelter stories--the first to exhaust air from the room with apertures and the second to supply air to the windowless room. PVK(s) are placed in a remote corner of the windowless room in larger shelter stories of this type. The duct(s) are passed through the doorway connecting the two rooms and out through the aperture(s) in the other room. Ventilators are allocated as recommended (Parts b and c of Figure B-30 show deployment plans).

**III-A-3c: Partitioned into Two Rooms of Comparable Size (Apertures in One Room Only--Multiple Apertures in Only One Wall)**

Figure B-31, part a, illustrates the use of a Kearny pump to supply air to a Configuration III-A-3c small shelter story. An additional Kearny pump supplies fresh air to the dead-end room. Parts b and c of Figure B-31 show the deployment of ventilators to ventilate two larger shelter stories of this type. PVK(s) are located in a remote corner of the room with no apertures and the duct(s) passed through the connecting doorway and out through the aperture(s). Ventilators are allocated as recommended to distribute the air.

**II-A-3d: Partitioned into Two Rooms of Comparable Size (Apertures in One Room Only--Single Aperture in Only One Wall)**

Figure B-32, part a, depicts the deployment scheme for the two Kearny pumps needed to ventilate a small shelter story of the configuration. One

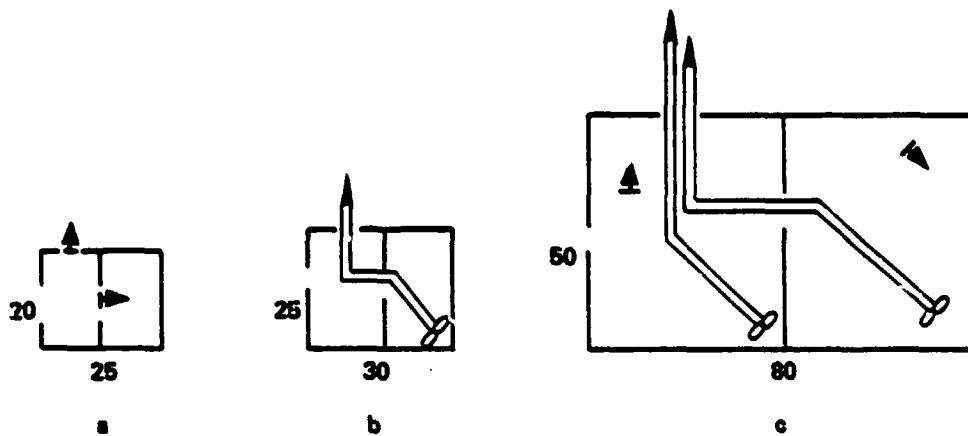


Figure B-30

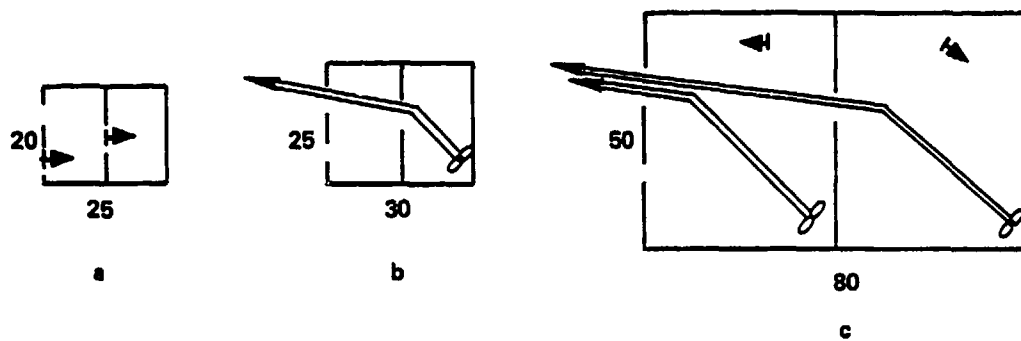
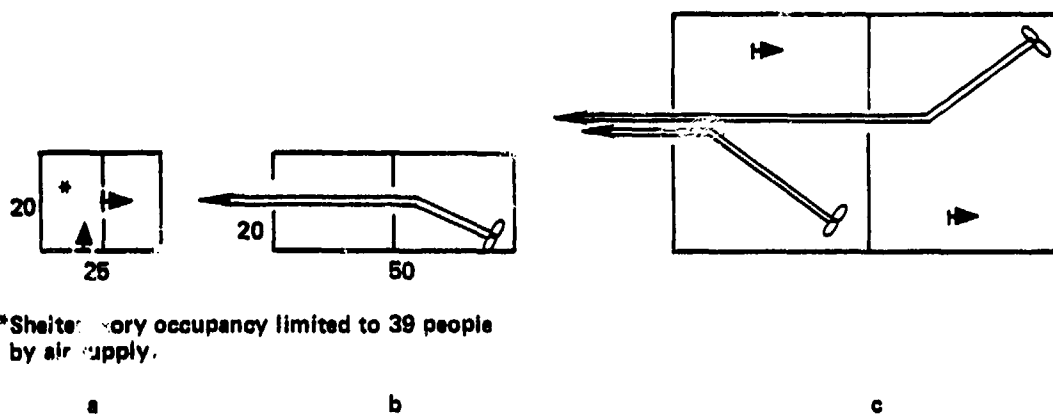


Figure B-31



\*Shelter occupancy limited to 39 people by air supply.

Figure B-32

Kearny pump supplies air to the shelter (a maximum of 590 cfm), and the second Kearny pump supplies air to the dead-end room. In a larger shelter story, PVK(s) should be placed in a remote corner of the dead-end room and air should be exhausted from the aperture in the other room (Figure B-32, part b). If more than one PVK is required, PVK(s) should be placed in remote corners of both rooms. The amount of air that can be supplied to the shelter story might be limited by the size of the single aperture. Kearny pumps will be needed for air distribution in larger shelter stories (Figure B-32, part c).

III-B-1: Partitioned into Three Rooms of Comparable Size in Series (Apertures in Wall of Both End Rooms)

Figure B-33, part a, illustrates the use of a Kearny pump to exhaust air from an aperture in one end room. Fresh air enters the aperture in the other end room and passes through the center room. Parts b and c of Figure B-33 show the use of PVKs to ventilate larger shelter stories in the same manner. If the apertures are well distributed in each of the rooms, no Kearny pumps should be needed for air distribution except in very large shelter stories.

III-B-2: Partitioned into Three Rooms of Comparable Size in a Series (Apertures in One End Room and in Middle Room)

Figure B-34, part a, illustrates the positioning of two Kearny pumps to ventilate a small shelter story of this configuration. A 6-foot Kearny pump is used to exhaust air from an aperture in the middle room, and a 3-foot Kearny pump supplies air to the dead-end room. In a larger shelter story, the PVK is placed in a remote corner of the dead-end room and the duct passed through the apertures in the center room (Figure B-34, part b). If multiple PVKs are required, the PVK(s) not needed in the dead-end room should be positioned to promote proper air mixing in the rooms with windows (Figure

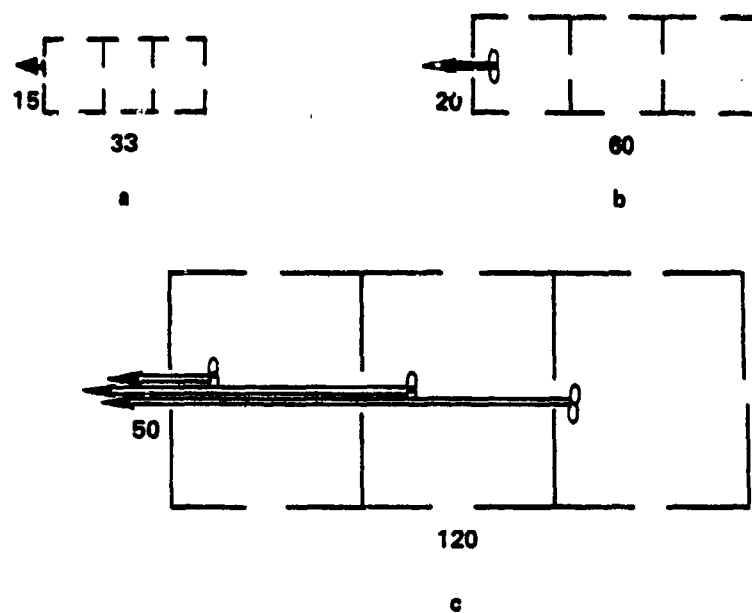


Figure B-33

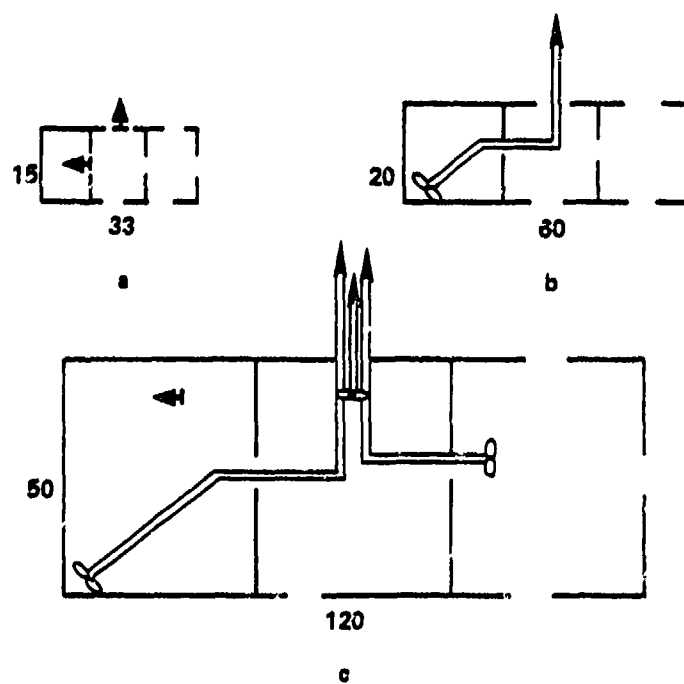


Figure B-34

B-34, part c). If the dead-end room is large, a Kearny pump may be needed achieve proper mixing of the air.

III-B-3: Partitioned into Three Rooms of Comparable Size in Series (Apertures in Middle Room Only)

Three Kearny pumps must be used to fully ventilate a ventilate a small shelter story of the type (Figure B-35, part a). A 6-foot Kearny pump supplies air to the middle room, and the end rooms are ventilated by a 3-foot Kearny pumps positioned in the doorways connecting the end rooms to the middle room. Figure B-35, part b, shows a larger shelter story, although small enough to require only one PVK to exhaust stale air. The PVK is placed in a remote corner of one of the end rooms, and a 3-foot Kearny pump supplies air to the other end room. If multiple PVK(s) are required (Figure B-35, part c) a PVK is placed in a remote corner of each of the end rooms. Kearny pumps are allocated as recommended for adequate air distribution.

III-B-4: Partitioned into Three Rooms of Comparable Size in Series (Apertures in One End Room Only)

As is the case with Configuration III-B-3, three Kearny pumps are needed to ventilate a small shelter story of this type. A 6-foot Kearny pump supplies air to the end room with apertures, and 3-foot Kearny pumps are placed in the connecting doorways to ventilate the two rooms with no apertures (Figure B-36, part a). In a shelter story requiring one PVK for ventilation, the PVK is placed in the end room with no apertures, and the duct is passed through the center room and out the apertures in the other end room (Figure B-36, part b). Figure B-36, part c, shows a shelter story requiring three PVKs, with one PVK positioned in each room. Kearny pumps are needed to distribute the air in the two rooms with no apertures.



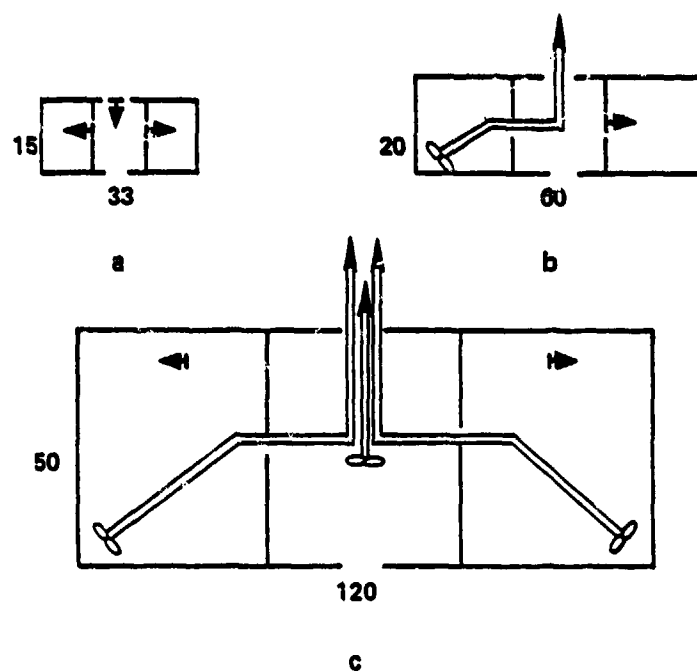


Figure B-35

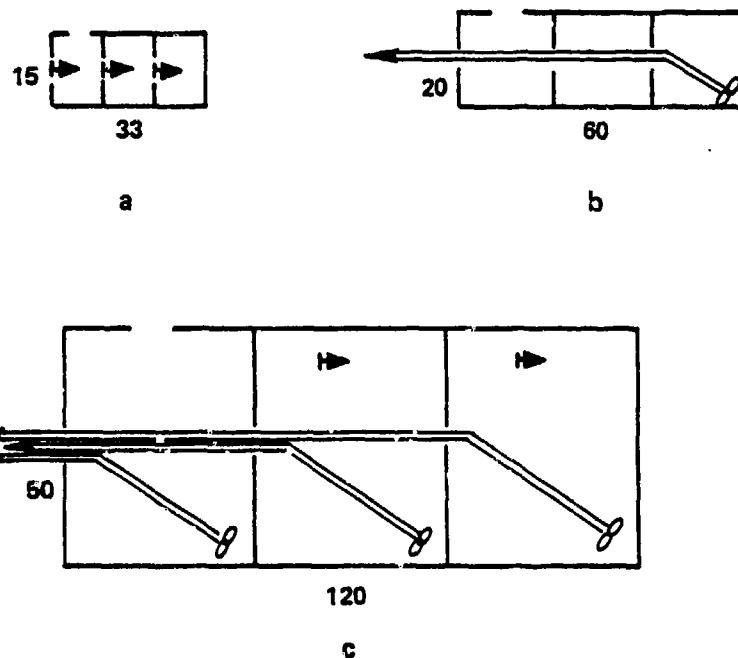


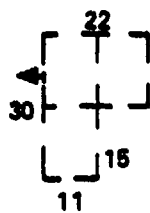
Figure B-36

III-C-1: Partitioned into Three Rooms of Comparable Size not in Series  
(Apertures in All Three Rooms)

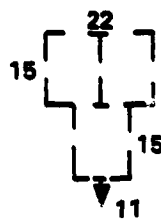
In a shelter story of this type, the stale air can be exhausted from any one of the three rooms, with fresh air entering the apertures not used for exhaust. Parts a and b of Figure B-37 show Kearny pumps used in this manner in small shelter stories. In larger shelter stories (Figure B-37, parts c and d) that still require only one PVK, the PVK is placed similarly to the Kearny pumps in the above examples. Parts e and f of Figure B-37 illustrate the placement of multiple PVKs in each room to promote adequate air distribution. No Kearny pumps should be needed for air distribution in this configuration except in very large shelter stories.

III-C-2: Partitioned into Three Rooms of Comparable Size not in Series  
(Apertures in Only Two Rooms)

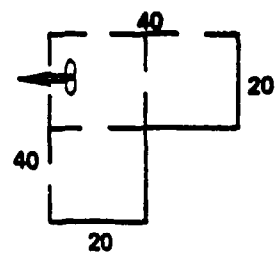
If possible, ventilators are placed so that air flows through all three rooms in series. Figure B-38, part a, shows a small shelter story ventilated in this manner with a Kearny pump. Figure B-38, part b, shows a larger shelter story in which a PVK is used to exhaust air so that fresh air flows throughout. If the rooms are large enough so that air distribution may be a problem, PVK(s) should be placed in each room and exhausted from a common aperture (Figure B-38, part c). Parts d, e, and f of Figure B-38 illustrate a configuration in which there is a dead-end room. Two Kearny pumps (one to exhaust air from the shelter, the second to supply air to the dead-end room) are required to ventilate a small shelter story of this type. PVK(s) should be placed in a remote corner of the dead-end room in larger shelters, and Kearny pump(s) may also be needed to distribute the air in any of the rooms without numerous, well-dispersed apertures.



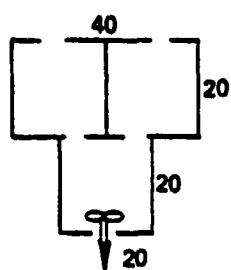
a



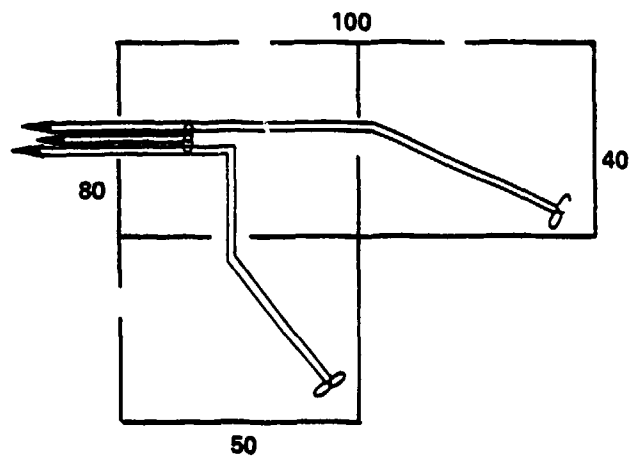
b



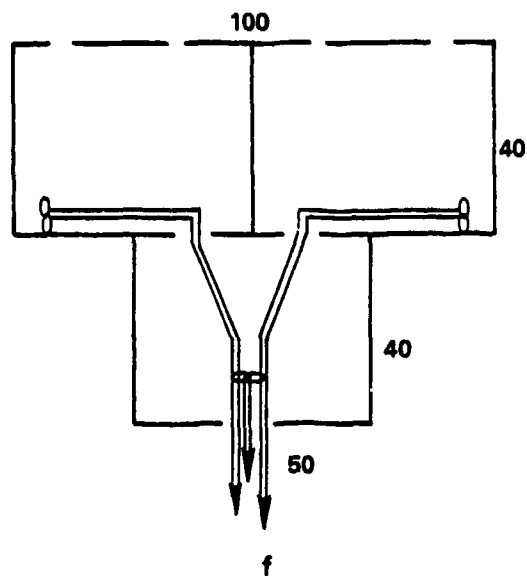
c



d



e



f

Figure B-37

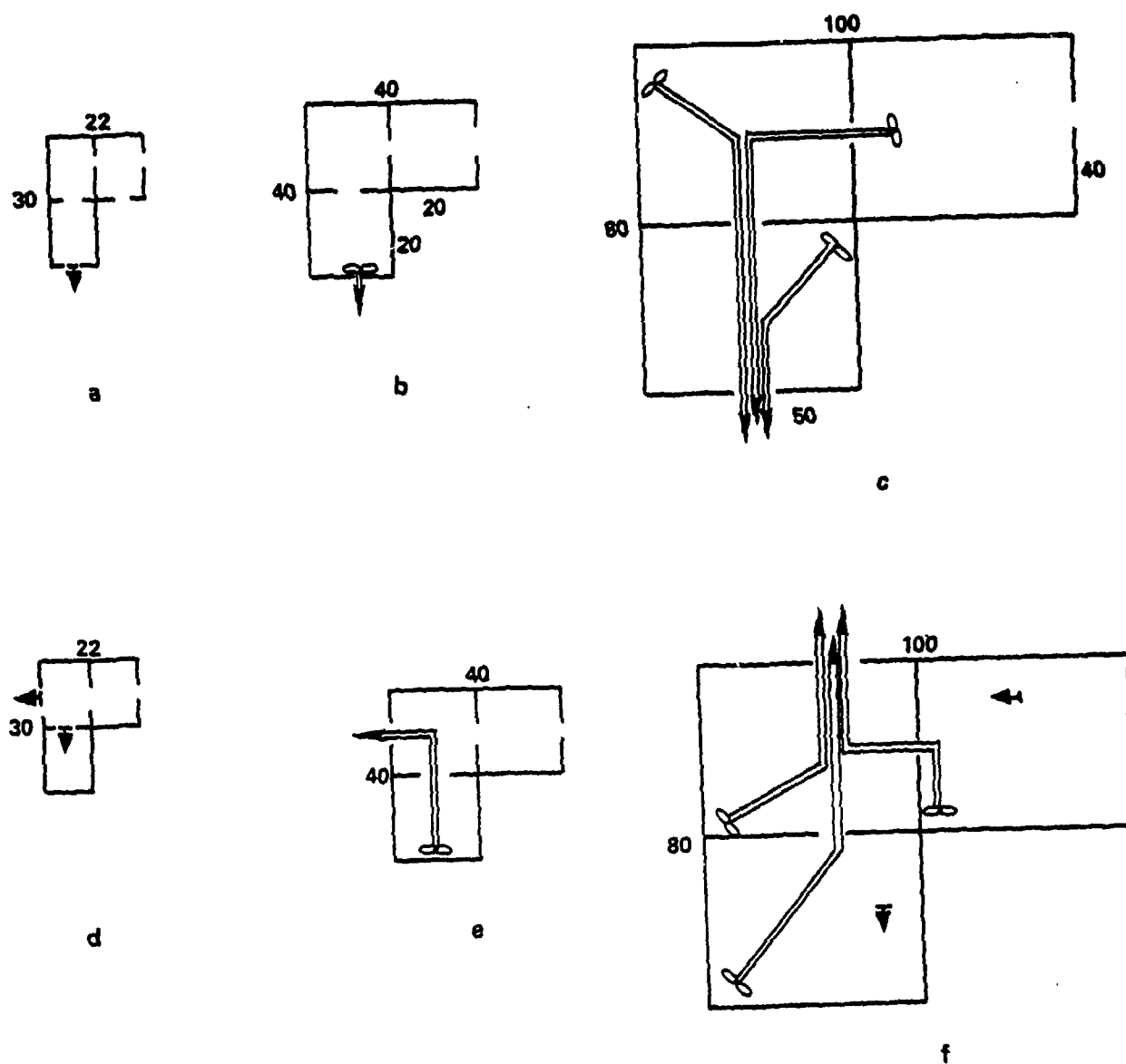


Figure B-38

III-C-3: Partitioned into Three Rooms of Comparable Size not in Series  
(Apertures in Only One Room)

Figures B-39, part a, illustrates a small shelter story of the configuration in which the two dead-end room are both adjacent to the room with apertures. In Figure B-39, part b, the dead-end rooms are in series with the room with apertures. Three Kearny pumps are required to ventilate the small shelter story in each case. A 6-foot Kearny pump is used to supply air to the shelter story, and a 3-foot Kearny pump supplies air to each dead-end room.

Figure B-39, part c, shows the deployment of a PVK and a Kearny pump to ventilate a larger shelter story with the two dead-end rooms both adjacent to the room with apertures. The PVK exhausts air from one of the dead-end rooms through one of the apertures in the adjoining room. The other apertures admit fresh air. The Kearny pump supplies air to the second dead-end room. If the dead-end rooms are in series (Figure B-39, part d), the PVK is placed in the end room, and the duct is passed through the middle room and out an aperture in the other end room. If multiple PVKs are required, a PVK is placed in each dead-end room and the stale air is exhausted through an aperture in the third room. Kearny pumps are needed to distribute the fresh air. Parts e and f of Figure B-39 depict large shelter stories with multiple PVKs.

III-D-1: Partitioned into Four or More Rooms of Comparable Size in Series  
(Apertures in Both End Rooms)

Parts a, b, and c of Figure B-40 show different sizes of the same configuration in which there are apertures in every room, so that proper mixing of the fresh air is relatively straightforward to achieve. A Kearny pump is placed to exhaust air from one of the end rooms in the small shelter story (Figure B-40, part a) and air enters through the aperture in the other

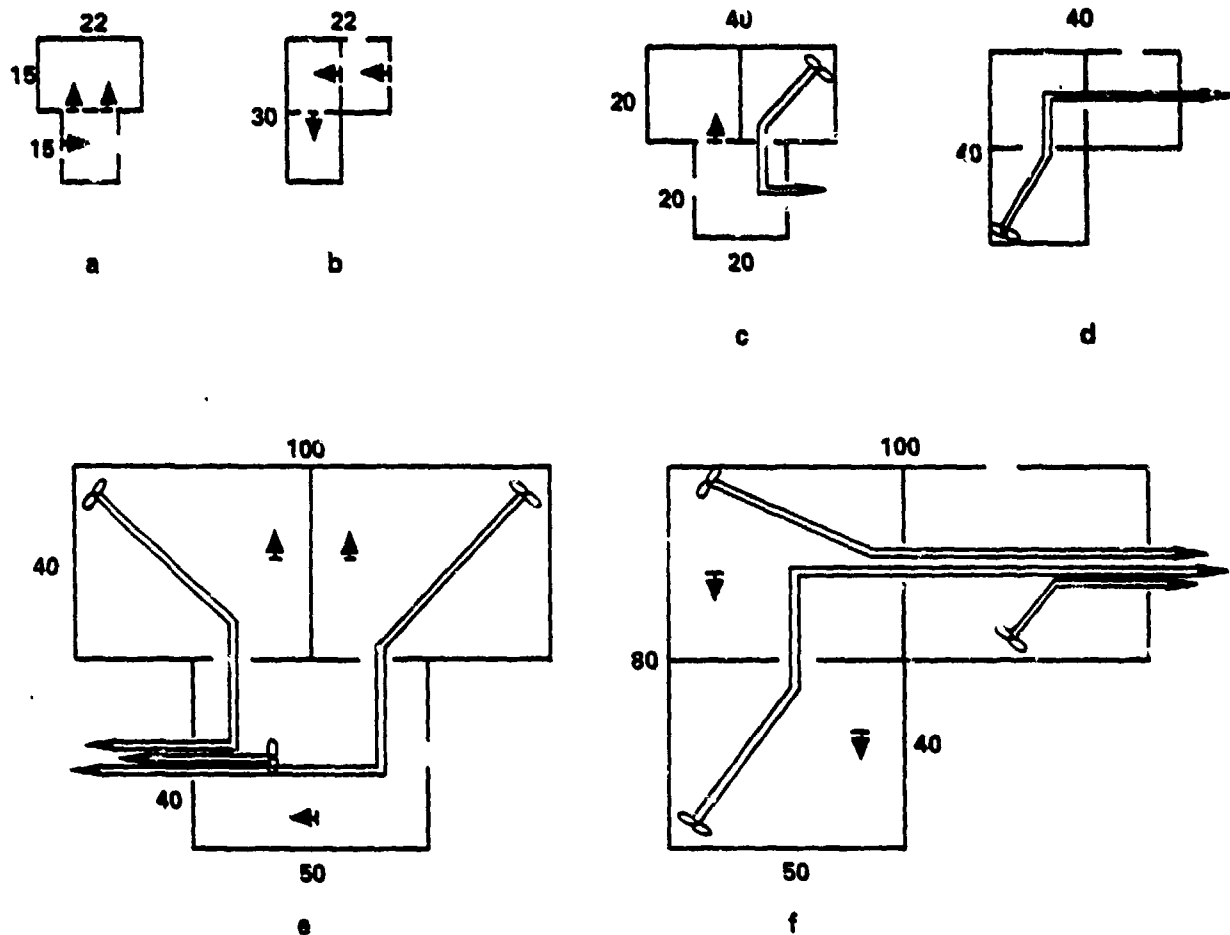


Figure B-30



Figure B-40

rooms and passes through the connecting rooms. The PVK is employed in this same manner in a larger shelter story (Figure B-40, part b). Placing the PVKs in each room of the large shelter story (Figure B-40, part c) aids in attaining proper mixing throughout. Only in very large shelter stories should Kearny pumps be needed to distribute the fresh air. Figure B-41, part d, illustrates a case where Kearny pumps are needed, because there are no apertures present in the middle rooms.

III-D-2: Partitioned into Four or More Rooms of Comparable Size in Series (Aperture in One End Room and All Middle Rooms, or in One End Room and the Middle Room Adjacent to the Other End Room)

Figure B-41, part a, illustrates the deployment of the two Kearny pumps required to ventilate a small shelter story of this configuration. A 6-foot Kearny pump is used to exhaust air from the shelter, and a 3-foot Kearny pump supplies air to the dead-end room. In a larger shelter story requiring one PVK, the PVK should be placed in the dead-end room with the duct positioned to exhaust air from an aperture in the adjacent room. Air enters the remaining apertures and flows through the series of rooms. Figure B-41, part b, illustrates this case. Figure B-41, part c, shows a larger shelter story requiring multiple PVKs. Placement of a PVK in each room helps to distribute the air, although Kearny pumps are still needed in rooms with limited apertures.

II-D-3: Partitioned into Four or More Rooms of Comparable Size in Series (Apertures in One End Room and the Adjacent Room Only, or in One End Room Only)

Three Kearny pumps are needed to ventilate a small shelter story of this type. Figure B-42, part a, depicts the use of a 6-foot Kearny pump to exhaust air from the room with apertures adjacent to the end room with apertures. Three-foot Kearny pumps supply air to the dead-end rooms. Figure

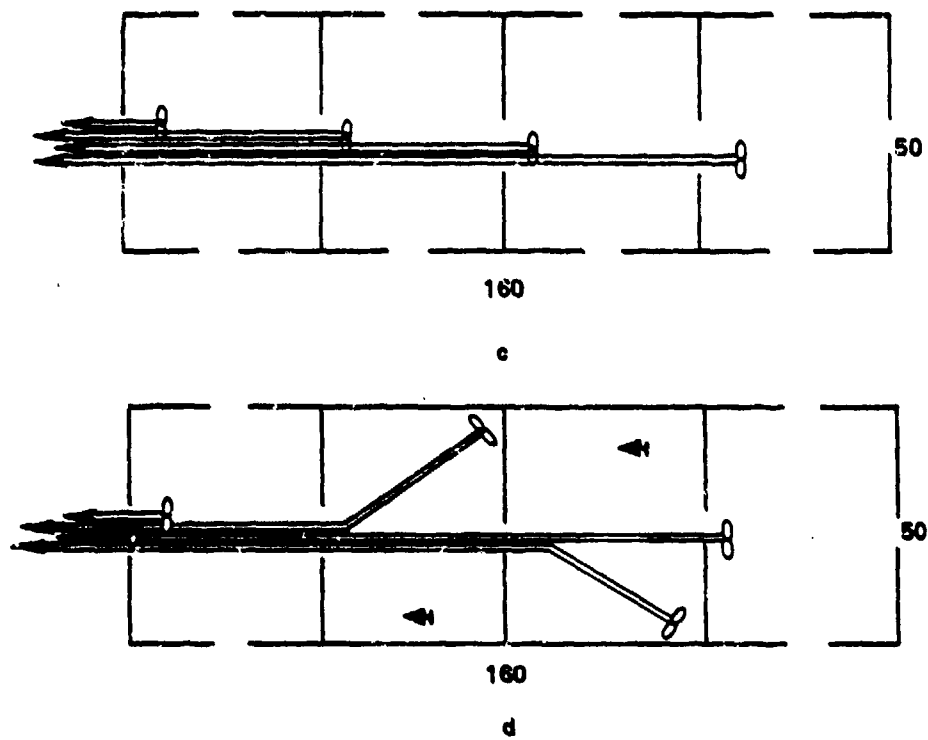


Figure B-40

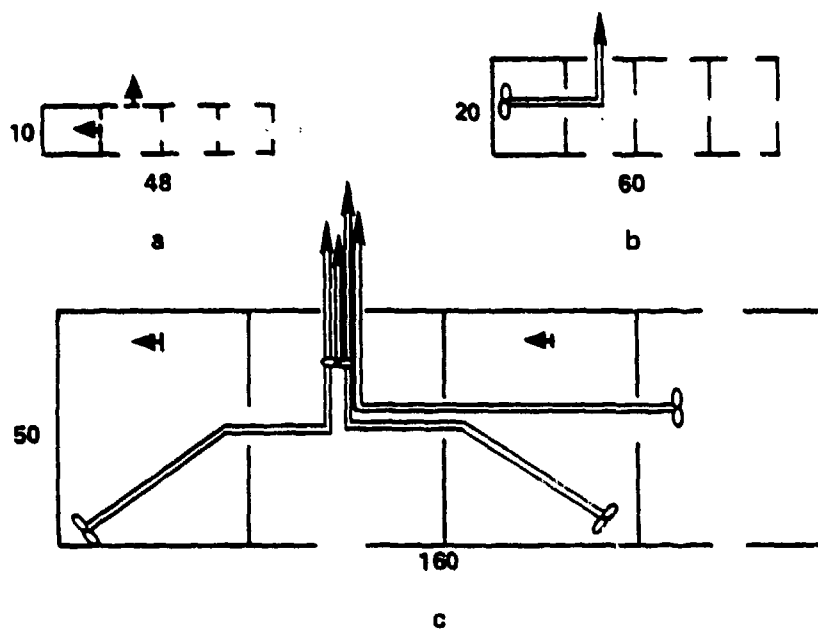


Figure B-41



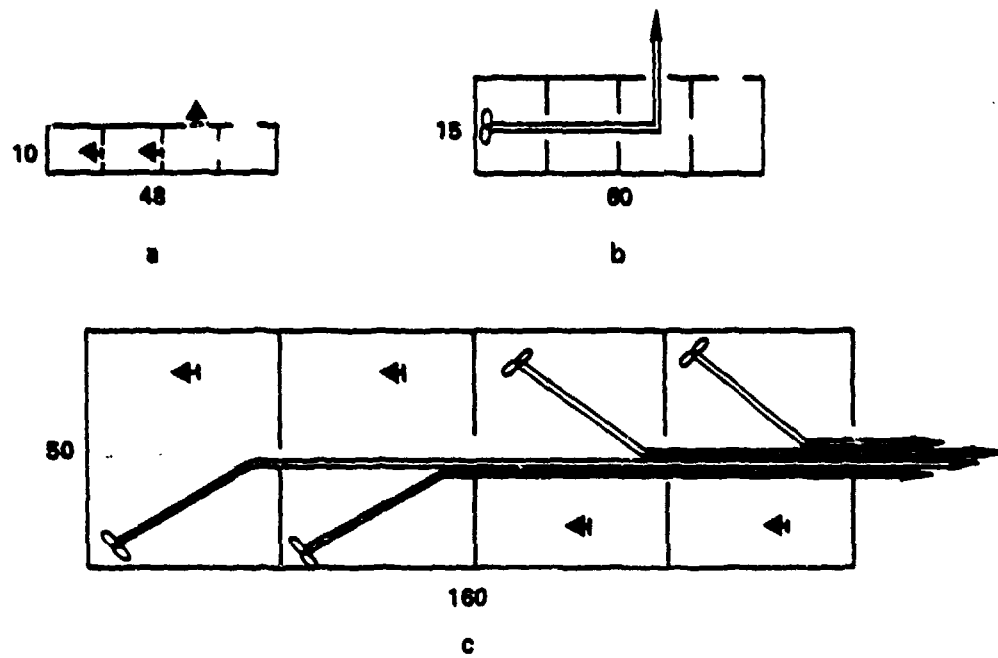


Figure B-42

B-42, part b, illustrates the placement of the PVK needed to ventilate a larger shelter in the end dead-end room. The duct is run through the adjacent windowless room and through an aperture in the next room. In a larger shelter story requiring multiple PVKs, the PVKs are placed in each room and Kearny pumps are deployed as recommended in the rooms where air distribution is a problem (Figure B-42, part c).

**III-D-4: Partitioned into Four or More Rooms of Comparable Size in Series (Aperture in Middle Rooms Only)**

Figure B-43, part a, illustrates the deployment of the three Kearny pumps required to ventilate a small shelter story of this configuration. A 6-foot Kearny pump supplies air to the shelter through an aperture in one of the middle rooms, and 3-foot Kearny pumps supply air to the dead-end rooms. Figure B-43, part b, shows the deployment plan for a larger shelter story, requiring one PVK to supply fresh air. The PVK is placed in a remote corner of one of the end rooms, and the duct is passed through the adjacent room and exhausts air from an aperture in the next room. Air is supplied to the other end room with a 3-foot Kearny pump. If multiple PVKs are required, PVK(s) are placed in each end room, exhausting air through apertures in the adjacent room. Figure B-43, part c, illustrates the placement of a PVK in each room of the shelter with Kearny pumps allocated as recommended for proper mixing of the fresh air.

**III-D-5: Partitioned into Four or More Rooms of Comparable Size in Series (Apertures in Some but not All Middle Rooms and None in End Rooms)**

Figure B-44, part a, depicts the ventilation plan for a small shelter story of this configuration. A 6-foot Kearny pump supplies air to the shelter, and a 3-foot Kearny pump supplies air to each of the windowless rooms. In the larger shelter story illustrated in Figure B-44, part b, the

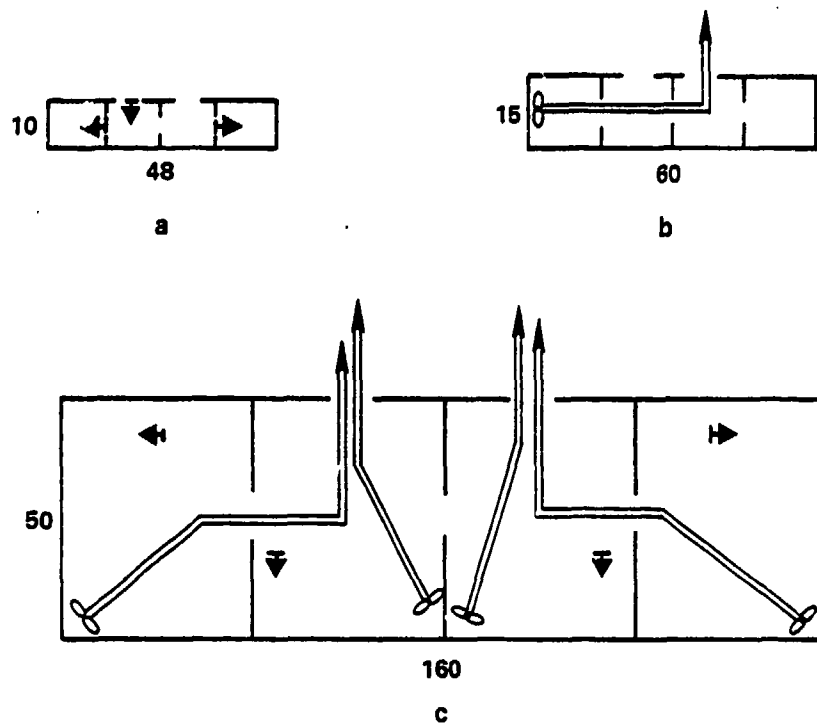


Figure B-43

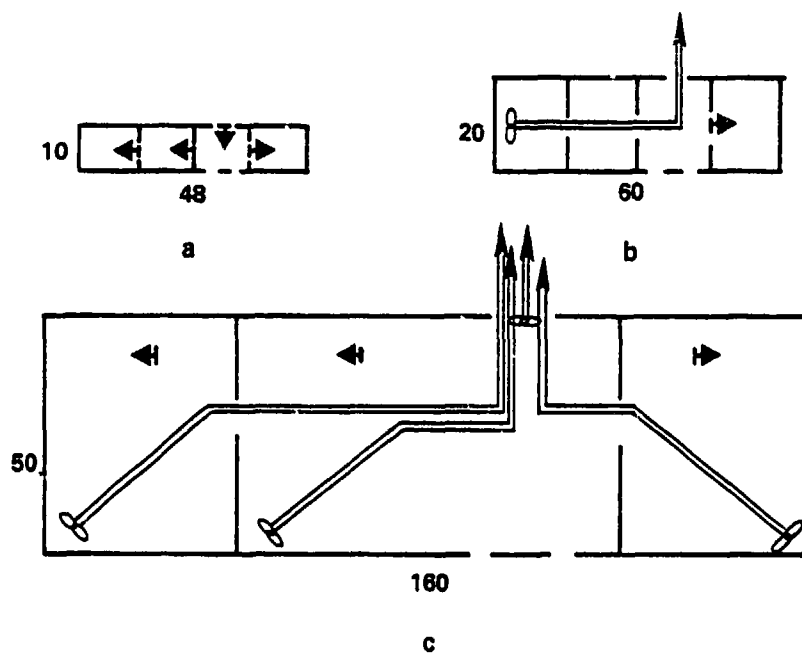


Figure B-44

single PVK is positioned in the end room furthest from the room with apertures. The duct is passed through the intervening room and exhausts air from an aperture. The other end room is ventilated with a Kearny pump placed in the doorway. Figure B-44, part c, shows a large shelter story that requires as many PVKs as it contains rooms. One PVK is placed in each room, and Kearny pumps are deployed to aid air distribution.

III-E-1: Partitioned into Four or More Rooms of Comparable Size not in Series (Apertures in All Rooms)

With apertures in all rooms, air distribution is a relatively minor consideration. The ventilation scheme consists of exhausting air from one or more apertures with fresh air allowed to enter the remaining apertures. Parts a through c of Figure B-45 illustrate the use of Kearny pumps to exhaust air from three different possibilities for small shelter stories of this configuration. Parts d through i of Figure B-45 show the deployment of PVKs to ventilate two larger sizes of each of the three possibilities. Kearny pumps may be needed in large rooms in which the apertures are not well distributed.

III-E-2: Partitioned into Four or More Rooms of Comparable Size not in Series (No Apertures in Some Rooms)

A large number of possibilities exist under this classification. Several variations in the orientations of the rooms exist and for each orientation, several aperture configurations are possible. No attempt is made to describe all of the possibilities, but several specific examples are shown.

In general for this classification, the ventilators should be placed in such a manner that air flows through as many rooms as possible. Parts a, b, and c of Figure B-46 depict deployment plans for Kearny pumps in small shelter stories. A 6-foot Kearny pump is used to exhaust air from or supply air to

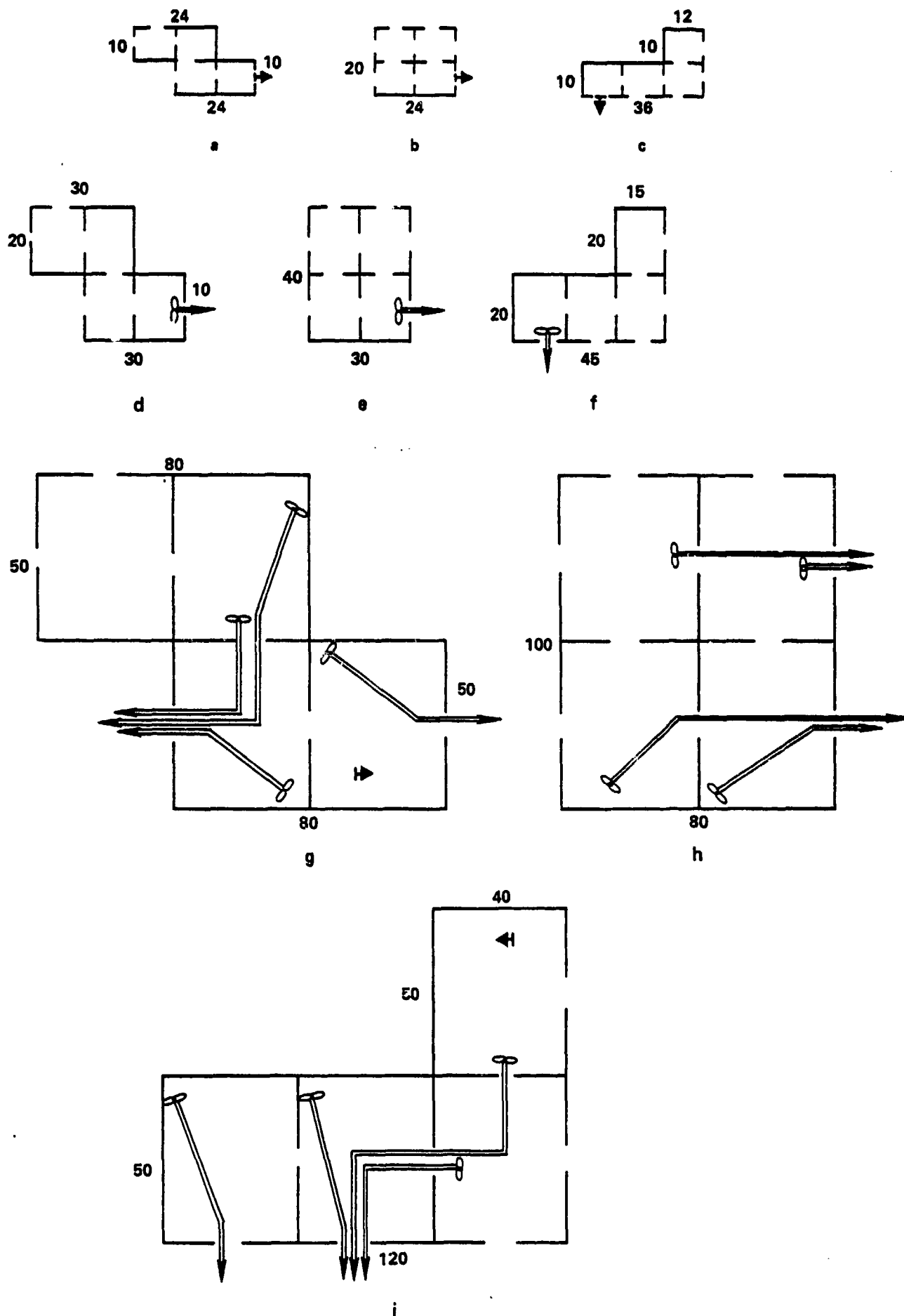


Figure B-45  
B-46

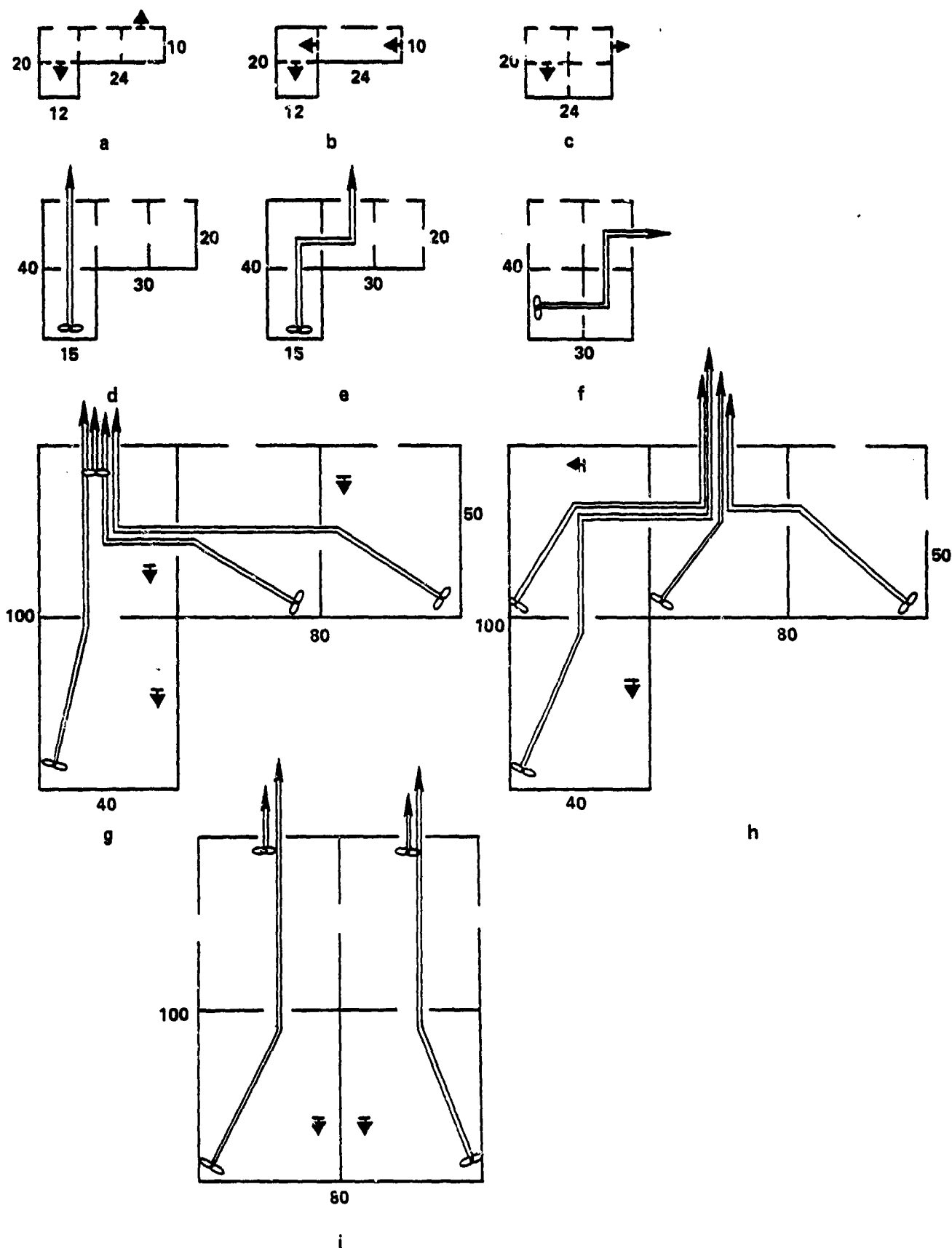


Figure B-43

each shelter story, and a 3-foot Kearny pump is used to supply air to each dead-end room. In Figure B-46, part c, a 6-foot Kearny pump is positioned in the interior doorway to prevent fresh air from short circuiting the adjacent windowless rooms. Parts d through i of Figure B-46 illustrate ventilation plans for larger shelter stories that require PVKs to supply a sufficient volume of air. The PVKs are placed to maximize the distribution of air, and Kearny pumps are allocated as recommended to aid in air distribution.

IV-A-1: Corridor with Rooms off Corridor (Apertures in the Corridor and in All or Part of the Rooms)

In a shelter story of this configuration, stale air is exhausted from the aperture(s) in the corridor and fresh air enters through the apertures in the rooms. Figure B-47, part a, shows the use of a Kearny pump to exhaust air from a small shelter story. The PVK in Figure B-47, part b, is used in the same manner to ventilate a larger shelter story. The multiple PVKs required by the shelter story depicted in Figure B-47, part c, are placed to aid the distribution of fresh air.

IV-A-2: Corridor with Rooms off Corridor (Apertures in all or part of Rooms but not in Corridor)

If there are apertures in all of the rooms, ventilators are placed in one or more rooms at one end of the corridor and fresh air enters through the other rooms and flows down the corridor. Figure B-48, part a, illustrates the ventilation of a small shelter story using a Kearny pump in this manner, and Figure B-48, parts b and c, show the use of PVKs to ventilate larger shelter stories. In shelter stories of this classification in which apertures are present in only part of the rooms, 3-foot Kearny pumps or PVKs must be used to supply air to the windowless rooms. Parts d through f of Figures B-48 show ventilation plans for shelter stories in which some rooms have no apertures.

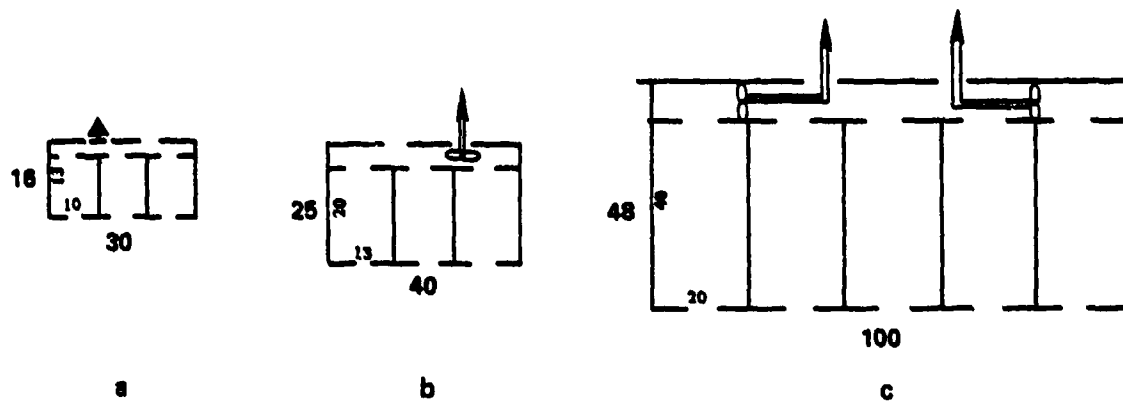


Figure B-47

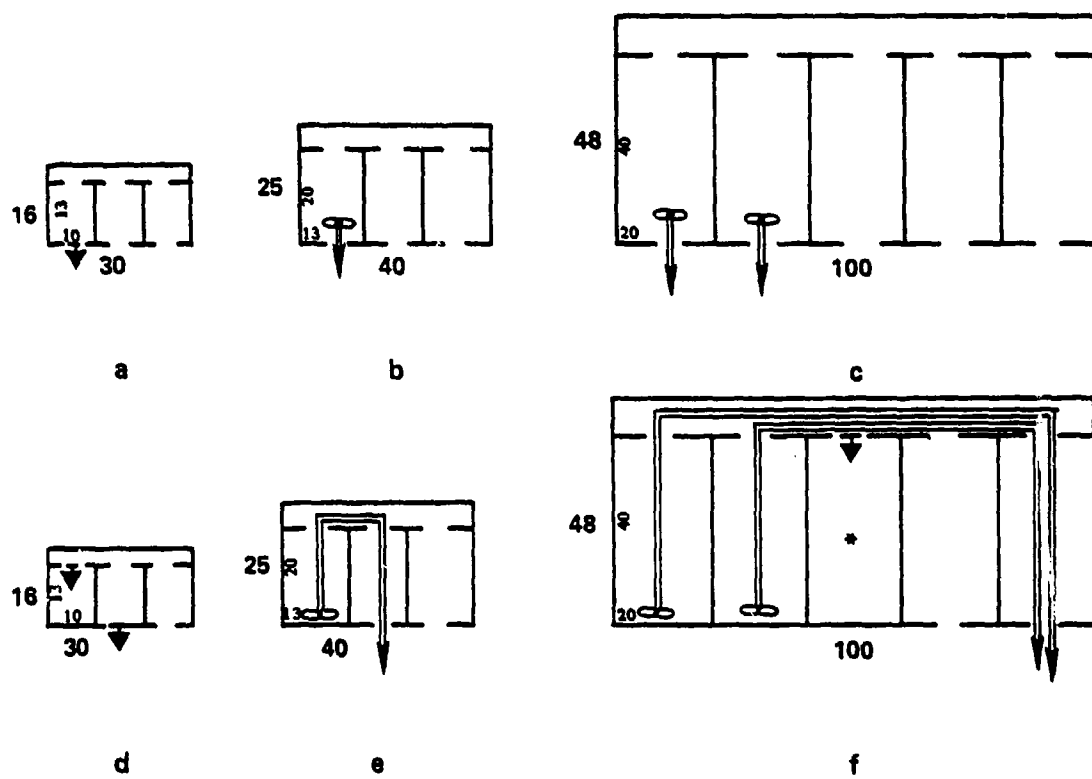


Figure B-48



IV-A-3: Corridor with Rooms off Corridor (Apertures in Corridor Only)

Figure B-49, part a, illustrates the deployment of four Kearny pumps to ventilate a small shelter story of this type. A 6-foot Kearny pump supplies air to the shelter, and 3-foot Kearny pumps supply air to the rooms. In larger shelter stories requiring PVKs, if the apertures are at or near the ends of the corridor, the PVKs are placed in rooms at one end of the story so that air flows the length of the corridor. Kearny pumps supply air to the rooms with no PVKs. Parts b and c of Figure B-49 illustrate this case. Parts d and e of Figure B-49 depicts shelter stories with the apertures occurring in only one end of the corridor and in the center of the corridor. PVK(s) are placed in the rooms at the end of the corridor with no aperture, and air is exhausted from apertures in the center. Kearny pumps supply air to the rooms with no PVKs.

V-A-1: Corridor (with Rooms off it) Joining Two Large Areas (Apertures in Both Large Areas and in All Small Rooms)

Figure B-50, part a, illustrates the use of a Kearny pump to ventilate a small shelter story of this configuration. Stale air is exhausted from one large area, and fresh air enters through each of the rooms and through the other large area. Figure B-50, part b, shows the use of a PVK to ventilate a larger shelter story in this same manner. In Figure B-50, part c, PVKs are placed in both large areas and fresh air enters through the rooms.

V-A-2: Corridor (with Rooms off at) Joining Two Large Areas (Apertures in All Small Rooms but none in Large Areas or Corridor)

Three Kearny pumps are needed to ventilate a small shelter story of the configuration (Figure B-51, part a). A 6-foot Kearny pump supplies fresh air to the shelter through an aperture in one of the rooms. Three-foot Kearny pumps distribute air to the large areas. In a larger shelter to which fresh

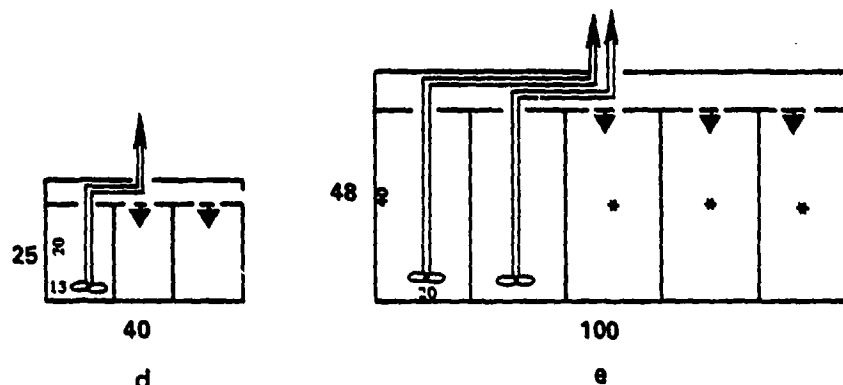
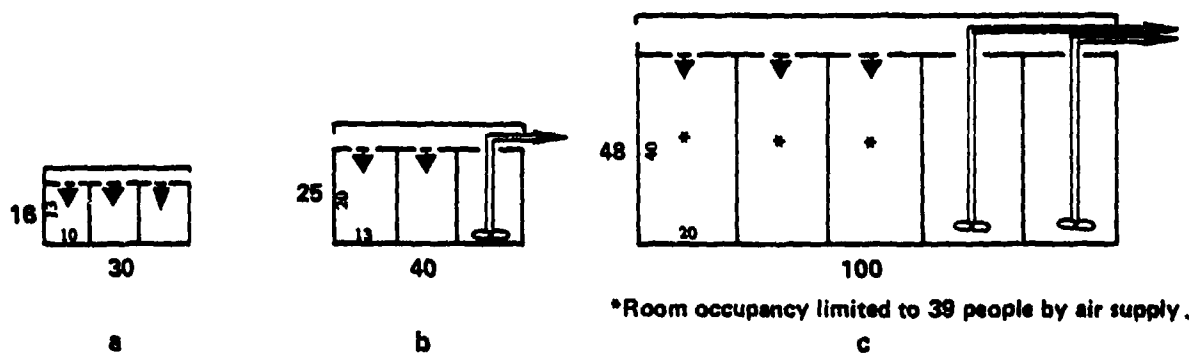


Figure B-49

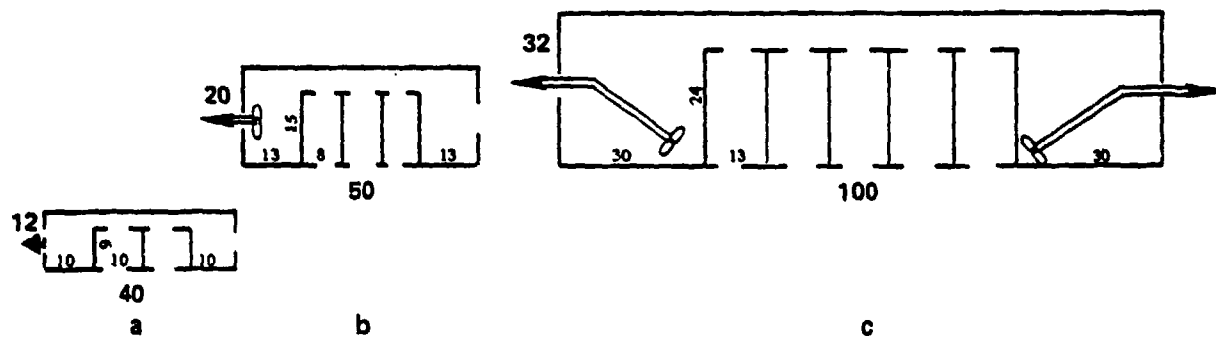


Figure B-50

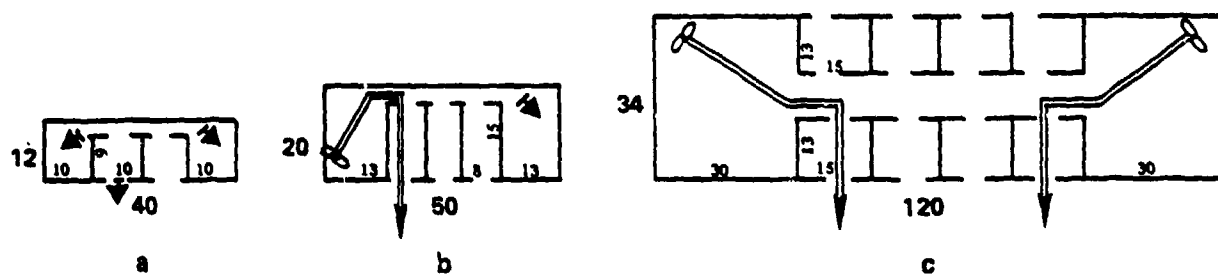


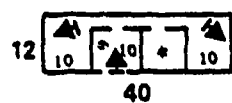
Figure B-51

air is supplied with a PVK, the PVK can be placed in one of the large areas. Air is exhausted through an aperture in one of the rooms and fresh air enters the other rooms. As Figure B-51, part b, illustrates a Kearny pump distributes air to the other large area. Figure B-51, part c, shows the placement of a PVK in each large area. Fresh air enters the aperture that are not used for exhaust.

V-A-3: Corridor (with Rooms off it) Joining Two Large Areas (Apertures in Some of the Small Rooms, but none in Corridor and one or both of Large Areas)

Parts a through c of Figure B-52 depict ventilation plans for three different sizes of this configuration in the case with no apertures in either large area. The small shelter story illustrated in Figure B-52, part a, has only one aperture so that a 3-foot Kearny pump will supply only enough air for 39 people. Kearny pumps distribute air to the large areas (each of which should be occupied by one person less than the floor capacity), and the dead-end room is not used. In the shelter story requiring only one PVK (Figure B-52, part b), a Kearny pump is needed to supply air to the large area without the PVK, and another Kearny pump ventilates the dead-end room. The shelter story that is large enough to require two PVKs needs Kearny pumps only to supply air to the dead-end rooms (Figure B-52, part c).

Parts d through f of Figure B-52 illustrate ventilation plans for the same three sizes of shelter story, but the case where there are apertures in one of the large areas. The apertures in the large area allow fresh air to enter and reduce the need for Kearny pumps to distribute air to this area. A sufficient volume of air can be supplied to the small shelter story (Figure B-52, part d) by a 6-foot Kearny pump to use fully it in this case.

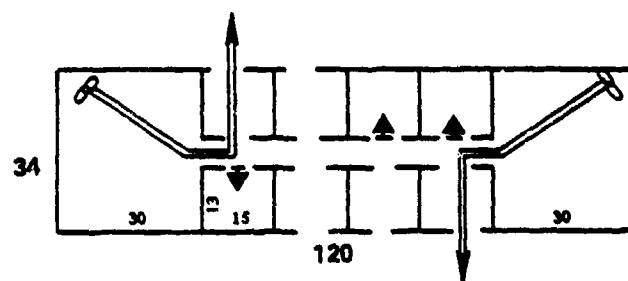


\*Dead-end room not utilized.  
Shelter capacity limited to  
39 people by air supply.

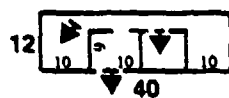
a



b



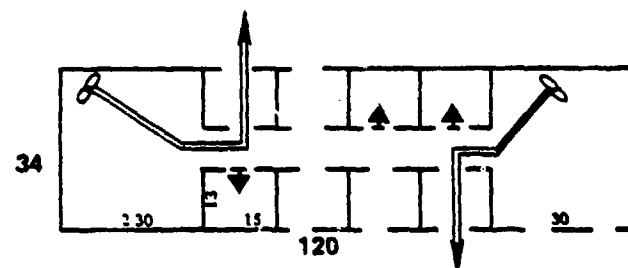
c



d



e



f

Figure B-52

V-A-4: Corridor (with Rooms off it) Joining two Large Areas (Apertures in both Large Areas but More in Corridor or Small Rooms)

The ventilation plan for this configuration consists basically of placing the ventilators to exhaust air from one large area and allowing fresh air to enter the other large area and pass down the corridor. Kearny pumps are used to supply air to the rooms off the corridor unless the rooms are large enough to require a PVK to be fully utilized and/or multiple PVKs are allocated to the shelter story. Figure B-53, part a, illustrates the use of Kearny pumps to ventilate a small shelter story of this type. Parts b and c of Figure B-53 shows ventilation plans for two larger shelter stories.

V-A-5: Corridor (with Rooms off it) Joining two Large Areas (Apertures in Corridor but None in Large Areas or Rooms off Corridor)

Figure B-54, part a, illustrates the ventilation plan for a small shelter story of this type. A 6-foot Kearny pump exhausts air from the shelter, and 3-foot Kearny pumps distribute air to the large areas (the dead-end rooms should receive adequate ventilation due to the aperture configuration). Figure B-54, part b, shows the deployment of ventilators for a larger shelter story. The PVK is placed to ventilate one large area, and Kearny pumps distribute fresh air to the other large area and the dead-end rooms. The shelter story depicted in Figure B-54 part c, requires two PVKs to supply an adequate volume of fresh air. The dead-end rooms are ventilated with Kearny pumps.

V-A-6: Corridor (with Rooms off it) Joining two Large Areas (Apertures in one Large Area Only)

Four Kearny pumps are needed to ventilate a small shelter story of this type. A 6-foot Kearny pump supplies air to the shelter and 3-foot Kearny pumps ventilate the large windowless area and the dead-end rooms. Figure

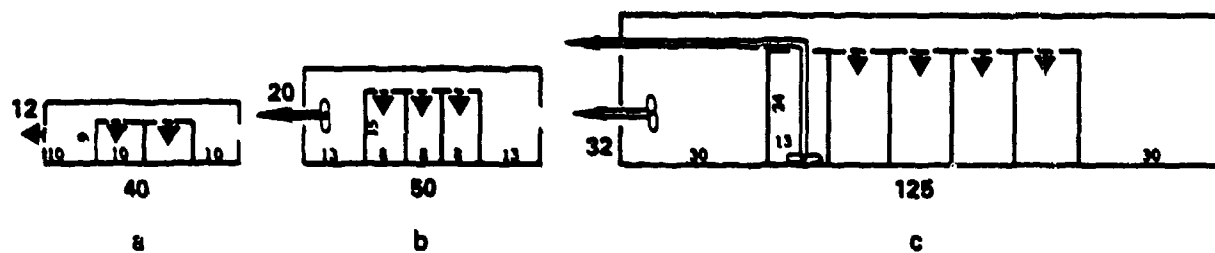


Figure B-53

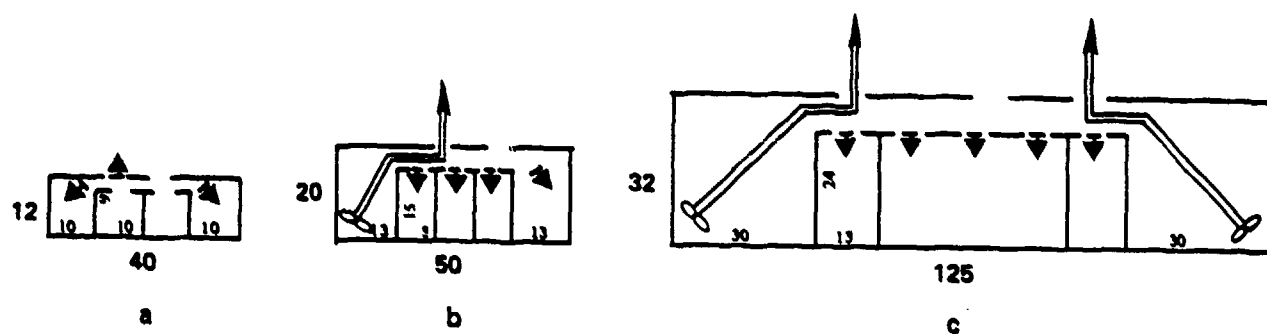


Figure B-54

B-55, part a, illustrates this deployment plan. Figure B-55, part b, shows the ventilation plan for a larger shelter that requires one PVK to supply a sufficient quantity of air. The PVK is placed in the large area with no apertures, and the duct is run down the corridor and through an aperture in the other large area to exhaust air. Kearny pumps supply air to the dead-end rooms. In the shelter story illustrated in Figure B-55, part c, the PVKs are placed in opposite corners of the windowless large area with both exhausting air from the same aperture. Fresh air enters the other aperture and is supplied to the windowless rooms by Kearny pumps.

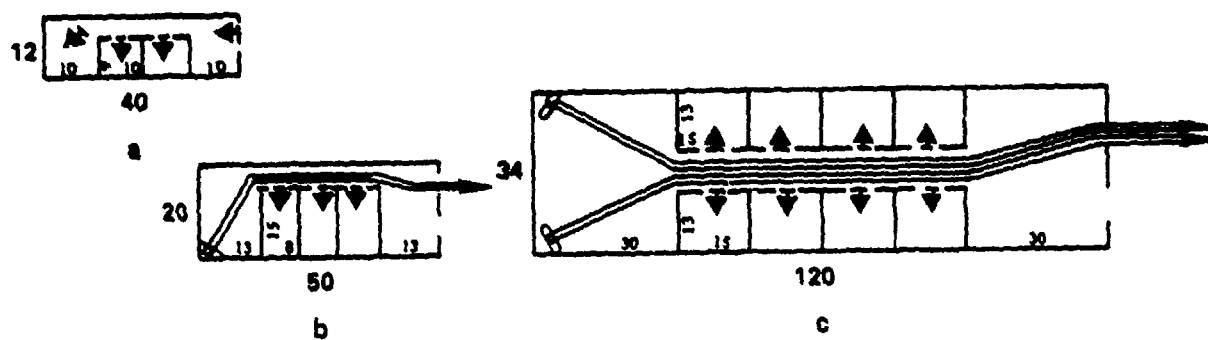


Figure B-55



APPENDIX C

VENTILATION EQUIPMENT ALLOCATION  
AND DEPLOYMENT PLANNING  
EXAMPLES FOR SPECIFIC SHELTER STORIES

## APPENDIX C

### VENTILATION EQUIPMENT ALLOCATION AND DEPLOYMENT PLANNING EXAMPLES FOR SPECIFIC SHELTER STORIES

This appendix contains six illustrative examples in the use of the ventilation kit allocation and deployment methodology described in Chapter III. Each of the six basic floor plans illustrated in Figure III-1 is represented by one of the specific shelter stories herein. Each building floor plan is derived from a building surveyed in the NSS or in the CRP Host Areas Facility Survey. Minor additions and modifications have been made to the floor plans for the sake of the example.

I. EXAMPLE NUMBER 1  
(WATERTOWN BOWLING CENTER)

The Watertown Bowling Center is located in a rural town in a southwestern state. It consists of one large room that contains the bowling lanes, front desk, and a small snack area. Supplies are stored in a small building adjacent to the Bowling Center. This building is an example of a single-room shelter (see Figure III-1).

Following are the steps taken to define a crisis-implemented ventilation system for the Watertown Bowling Center. The steps correspond to the procedure described in Chapter III.

- A. There are 2,520 square feet of floor area usable for shelter space. This will accommodate 252 shelter occupants at 10 square feet per person.
- B. The county in which Watertown is located has a zonal ventilation requirement of 40 cfm per occupant; therefore, a total of 10,080 cfm (252 occupants x 40 cfm per occupant) of ventilation is needed.
- C. For an average effective duct length of 100 feet, 3 PVKs are needed (see Table III-1).
- D. At least 14.7 square feet (3 PVKs x 4.9 square feet per PVK) of aperture area are needed for the exhaust ducts and for the air inlets. The door through which air is to be exhausted is 18 square feet. The total aperture area of potential air inlets is 128 square feet.
- E. Since adequate aperture area is available, no adjustments in airflow are necessary.
- F. Configuration I-A-1 (see Appendix B) is representative of the Watertown Bowling Center.
- G. No Kearny pumps are needed as air mixers because of the placement of the PVKs.
- H. No Kearny pumps are needed to supply air to dead-end rooms.

- I. The equipment deployment in the Watertown Bowling Center is illustrated in Figure C-1. The windows close to the PVKs are not opened so fresh air will enter at one end of the shelter and circulate throughout. Modifications should be made to this deployment plan if all of the air inlets cannot be left open due to fallout protection upgrading or if there are areas of stale air within the shelter.

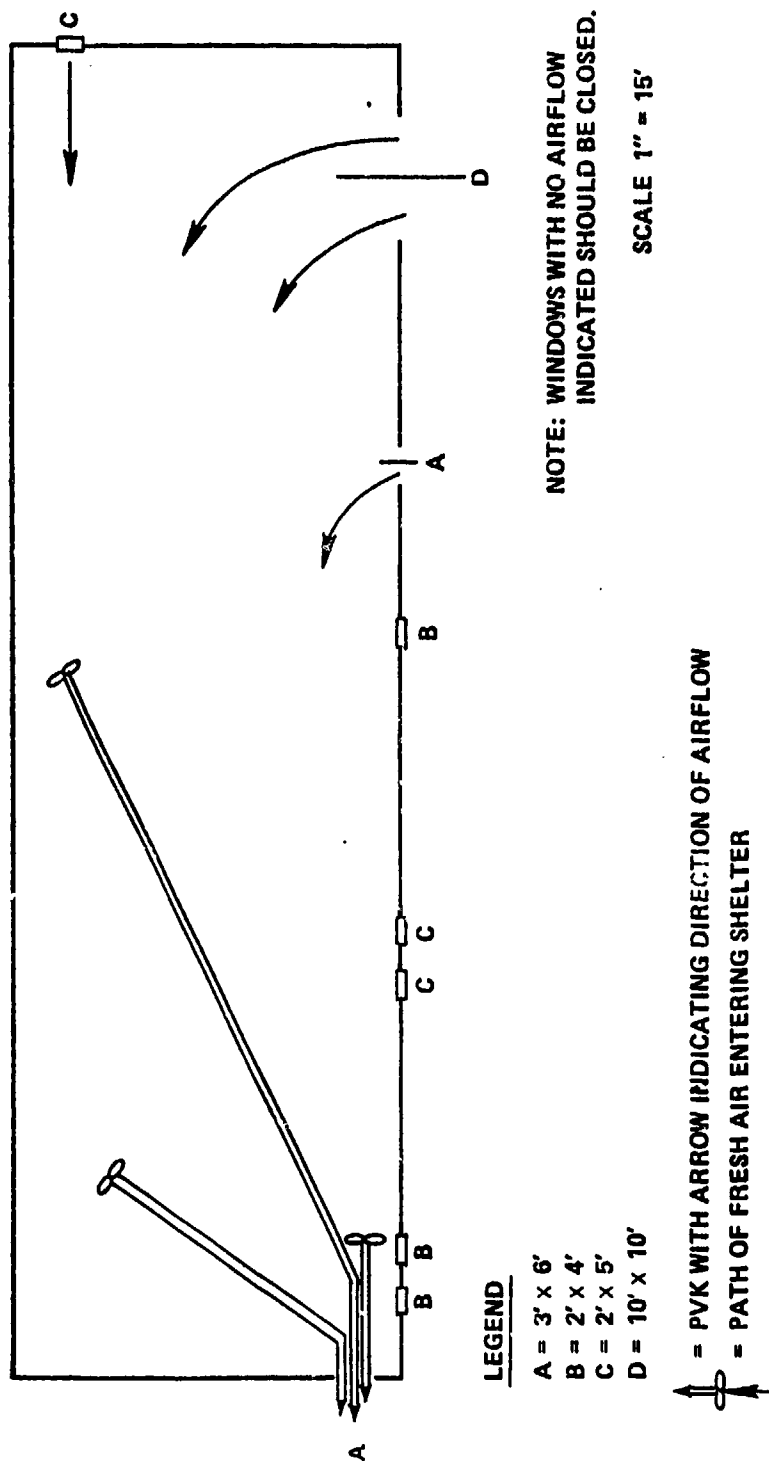


Figure C-1. Ventilation Plan For Watertown Bowling Center

## II. EXAMPLE NUMBER 2

### (S-MART DEPARTMENT STORE)

The S-Mart Department Store is located in a Middle Atlantic state. It is part of a regional chain of department stores and carries a diverse mix of merchandise, ranging from clothing to hardware. It consists of a large floor divided into departments by counters, shelves, low partitions, and stockrooms about the perimeter of the building. This is an example of a large area with small adjoining rooms (see Figure III-1).

Following are the steps taken to define a crisis-implemented system for the S-Mart Department Store. The steps correspond to the procedure described in Chapter III.

- A. The usable floor area is 20,640 square feet, which will accommodate 2,064 shelter occupants at 10 square feet per person.
- B. The S-Mart Department Store is located in a county with a zonal ventilation requirement of 20 cfm/occupant; therefore, the total volume of ventilation that is needed is 41,280 cfm (2,064 occupants x 20 cfm/occupant).
- C. For an average effective duct length of 200 feet, 12 PVKs are needed (Table III-1).
- D. At least 58.8 square feet (12 PVKs x 4.9 square feet per PVK) of aperture area are needed for the exhaust ducts and for the air inlets. The doors through which air is to be exhausted total 371 square feet. The total area of the inlet apertures is 308 square feet.
- E. Since adequate aperture area is available, no adjustments in airflow are necessary.
- F. Configuration II-A-2 (see Appendix B) is representative of the S-Mart Department Store.
- G. No Kearny pumps are needed as air mixers because of the placement of the PVKs.
- H. Five 3-foot Kearny pumps are needed to supply air to dead-end rooms.

- I. Figure C-2 illustrates the deployment of ventilation equipment in the S-Mart Department Store. Modifications should be made to this deployment plan if all of the exhaust and inlet apertures cannot be left open due to fallout protection upgrading or if there are areas of stale air within the shelter.

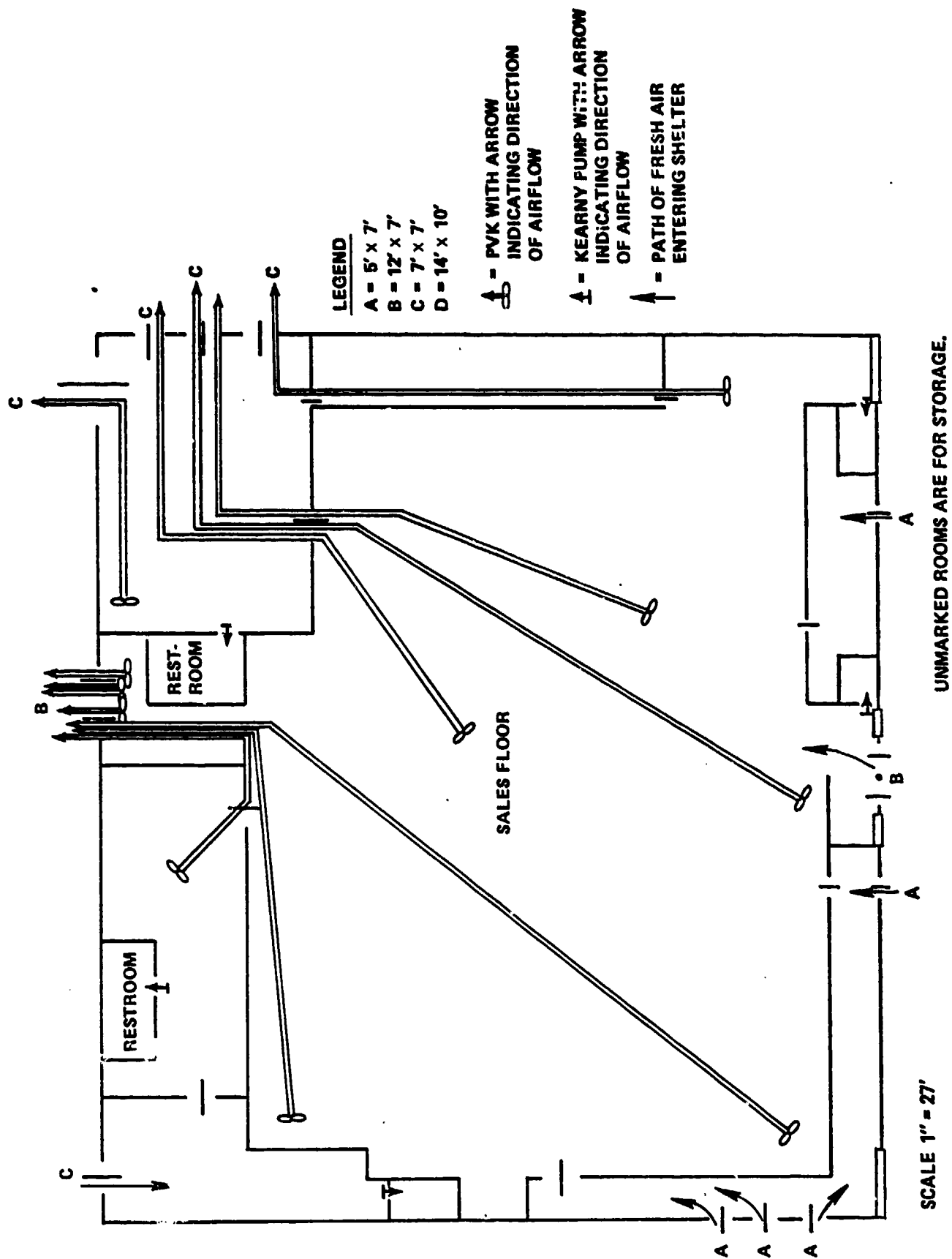


Figure C-2. Ventilation Plan for S-Mart Department Store



### III. EXAMPLE NUMBER 3

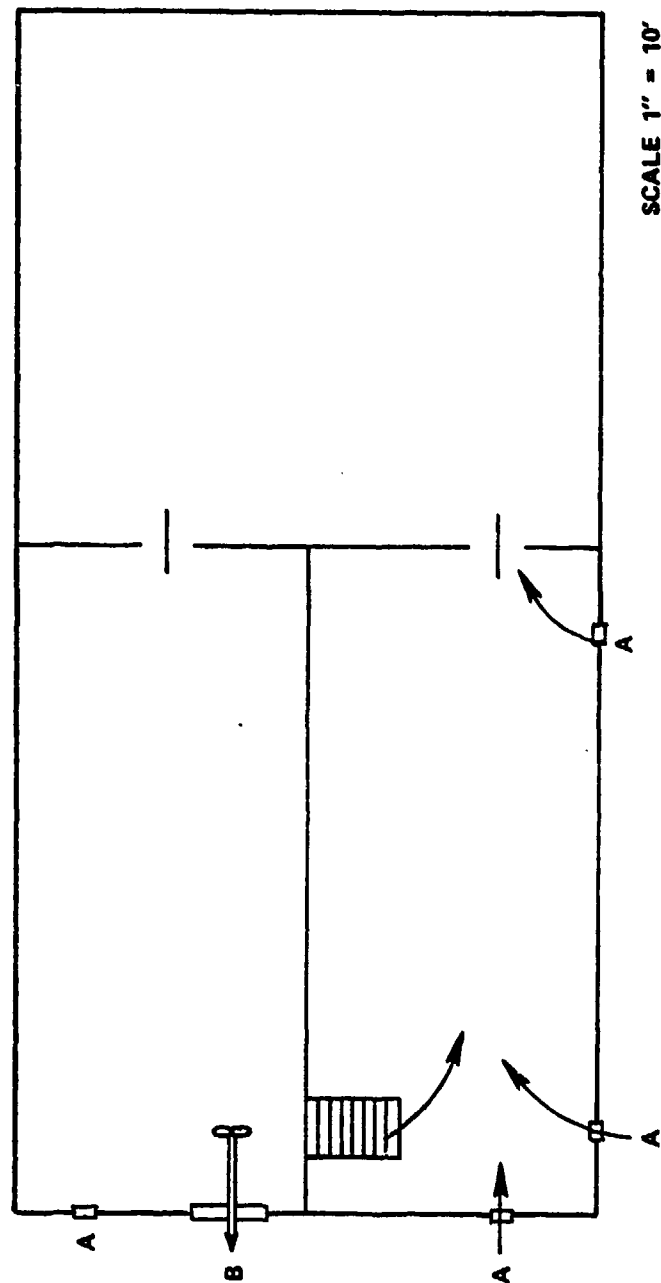
#### (OK DINER)

A small town in a midwestern state is the location of the OK Diner. The diner has a full basement, which is where the upgradable shelter space is located. The basement is composed of three rooms that are used for the storage of supplies such as canned goods, kitchen equipment and tables and chairs. This facility is an example of a shelter that is partitioned into rooms of comparable size (see Figure III-1).

Following are the steps used in defining a crisis-implemented ventilation system for the OK Diner. The steps correspond to the procedure described in Chapter III.

- A. The basement of the OK Diner contains 840 square feet of usable shelter area. At 10 square feet per person, 84 people can be sheltered there.
- B. The zonal ventilation requirement is 10 cfm per person in the county in which the OK Diner is located. A total of 840 cfm of ventilation is needed.
- C. Only 1 PVK (see Table III-1) is needed to exhaust stale air from the basement of the OK Diner.
- D. An aperture area of at least 4.9 square feet is needed both for the exhaust duct and for the air inlet. The door through which air is to be exhausted is 24 square feet. The total area of the inlet windows is 9 square feet, and fresh air also enters through the stairwell.
- E. Adequate apertures are available; therefore, no adjustment in airflow is needed.
- F. The basement of the OK Diner is best represented by Configuration III-C-2 (see Appendix B).
- G. No Kearny pumps are needed to mix air since fresh air flows through the 3 rooms as if they were in series.
- H. There are no dead-end rooms requiring Kearny pumps.

- I. The deployment of the PVK is illustrated in Figure C-3. Care must be taken in placing the exhaust duct so that the stale air does not enter the first floor and recirculate down the stairwell. It may be necessary to extend the exhaust duct as much as 35 feet beyond the aperture.



**LEGEND**

A = 1' x 3'  
B = 4' x 6'

A = PVK WITH ARROW INDICATING DIRECTION OF AIRFLOW  
A = PATH OF FRESH AIR ENTERING SHELTER

SCALE 1" = 10'

Figure C-3. Ventilation Plan For OK Diner

#### IV. EXAMPLE NUMBER 4

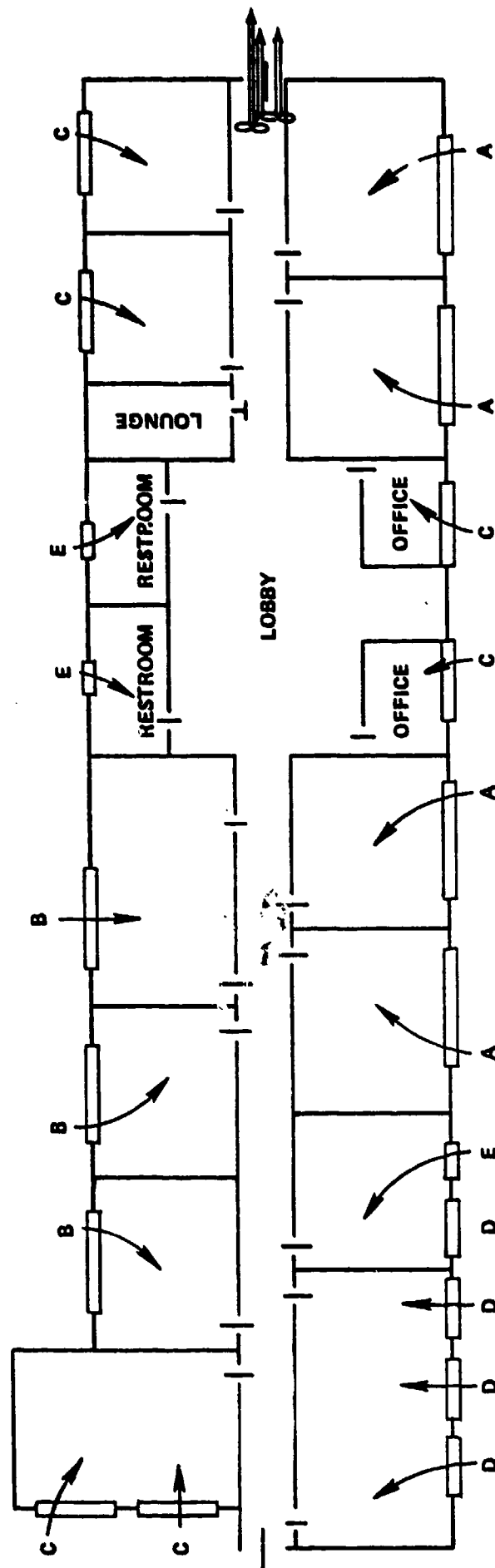
##### (MADISON SCHOOL)

Madison School is a rural New England high school that was constructed in 1923 and contains grades 10 through 12. The building used in this example consists of 12 classrooms and 2 offices. It represents a facility composed of a corridor with rooms off the corridor (see Figure III-1). A separate building (not included here) houses the gymnasium, cafeteria, and 4 classrooms.

A crisis-implemented ventilation system for Madison School is defined in the following steps. The steps are described in detail in Chapter III.

- A. Madison School contains 10,400 square feet of floor area usable as shelter space; hence, 1,040 shelter occupants can be accommodated.
- B. The county in which Madison School is located has a zonal ventilation requirement of 10 cfm per occupant. The 1,040 shelter occupants would require 10,400 cfm (1,040 occupants x 10 cfm per occupant) of ventilation.
- C. For an average effective duct length of 100 feet, 3 PVKs (see Table III-1) are required to ventilate Madison School.
- D. Three PVKs require at least 14.7 square feet (3 PVKs x 4.9 square feet per PVK) of aperture area for the exhaust ducts and another 14.7 square feet of aperture area for air inlet. Much more than adequate aperture area is available if the windows and doors are not closed in upgrading for fallout protection.
- E. Adequate apertures are available; hence, no adjustment in airflow is needed.
- F. Configuration IV-A-1 (see Appendix B) is representative of Madison School.
- G. No Kearny pumps are needed to distribute fresh air since air flows through the shelter from one end to the other, and since there are no large areas.
- H. One 3-foot Kearny pump is needed to supply air to a dead-end room. One of the PVKs could be placed to exhaust air from this room, but a Kearny pump is used instead since the room is relatively small.

- I. The equipment deployment in Madison School is illustrated in Figure C-4. The windows close to the PVKs should be opened only enough to allow fresh air to enter the rooms. If they were opened too much, insufficient quantities of fresh air would enter the rooms at the opposite end of the building.



# LEGEND

- A = 18 3/4' x 7' D = 9 3/8' x 7'
- B = 15 5/8' x 7' E = 6 1/4' x 7'
- C = 12 1/2' x 7'

↑ = PVK WITH ARROW INDICATING DIRECTION OF AIRFLOW

↑ = KEARNY PUMP WITH ARROW INDICATING DIRECTION OF AIRFLOW

↑ = PATH OF FRESH AIR ENTERING SHELTER

SCALE 1" = 25'

NOTE: WINDOWS CLOSE TO VENTILATORS  
SHOULD BE ONLY SLIGHTLY OPENED;  
UNLABELED ROOMS ARE CLASSROOMS.

Figure C-4. Ventilation Plan For Madison School

## V. EXAMPLE 5

### (DAWSON HALL)

Dawson Hall is the physics building at a private liberal arts college located in a Middle Atlantic state. The east and west wings of the building house a general laboratory and a lecture room, respectively. The remainder of the building is partitioned into three smaller laboratories and two offices. This facility is an example of a corridor (with rooms off it) joining two large areas (see Figure III-1).

The following steps define a crisis-implemented ventilation system for Dawson Hall. A detailed description of each step in the procedure is contained in Chapter III.

- A. Dawson Hall will accommodate 510 people in a crisis situation, with 10 square feet per person being allowed within 5,100 square feet of usable floor area.
- B. Dawson Hall is located in a county with a zonal ventilation requirement of 15 cfm per occupant; hence, a total of 7,650 cfm (510 occupants x 15 cfm per occupant) of ventilation is required.
- C. Two PVKs (see Table III-1) are needed to exhaust air, if an average effective duct length of 100 feet is assumed.
- D. At least 9.8 square feet (2 PVKs x 4.9 square feet per PVK) of aperture area are needed to accommodate the exhaust ducts and for the air inlets. More than enough apertures are available unless they are closed in upgrading for fallout protection.
- E. Since adequate aperture area is available, no adjustments in airflow are necessary.
- F. Dawson Hall is best represented by Configuration V-A-1 (see Appendix B).
- G. Because of the large number of apertures, and the airflow from one end of the shelter to the other, no Kearny pumps are needed to distribute fresh air.

- H. There are no dead-end rooms in Dawson Hall requiring 3-foot Kearny pumps to supply air.
- I. The deployment of PVKs in Dawson Hall is illustrated in Figure C-5. Windows with no airflow indicated should be closed, and windows close to the PVKs should be opened only slightly so that sufficient quantities of fresh air will flow throughout the shelter.



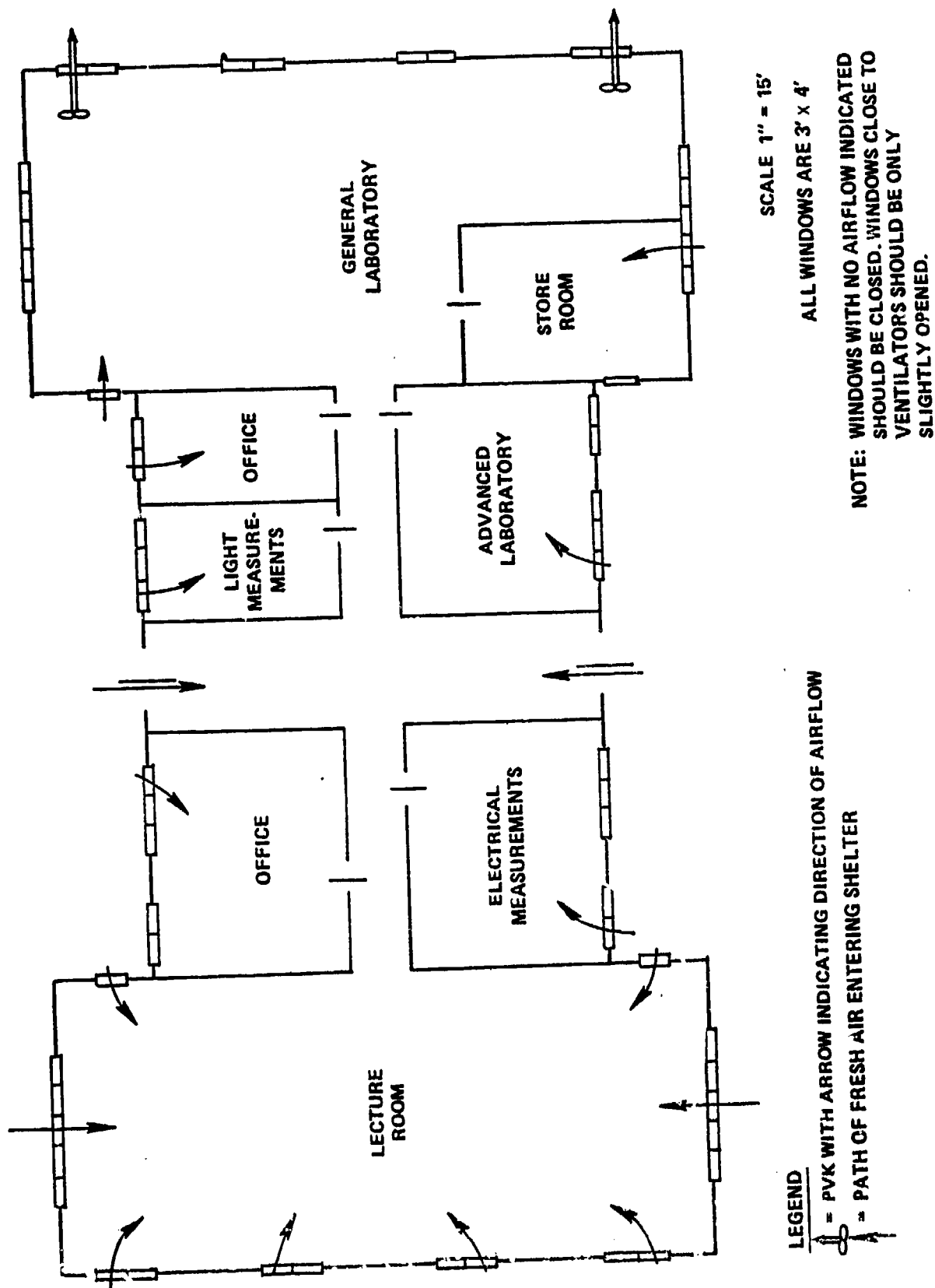


Figure C-5. Ventilation Plan For Dawson Hall

## VI. EXAMPLE NUMBER 6

### (BASSETT BUILDING)

The Basset Building is a rural county office building located in the Pacific Northwest and is an example of a complex configuration (see Figure III-1). It contains 38 offices and a conference room.

Following are the steps taken to define a crisis-implemented ventilation system for the Bassett Building. The steps correspond to the procedure described in Chapter III.

- A. The floor area usable for shelter in the Bassett Building totals 11,502 square feet, which will accommodate 1,150 shelter occupants.
- B. The Bassett Building is located in the zone in which the ventilation requirement is 7.5 cfm per occupant; therefore, a total of 8,625 cfm (1,150 occupants x 7.5 cfm/occupant) of ventilation is needed.
- C. For an average effective duct length of 200 feet, 3 PVKs (see Table III-1) are required to exhaust air from the Bassett Building.
- D. To accommodate 3 PVKs, at least 14.7 square feet of aperture area are needed for the exhaust ducts and also for the air inlets. Much more aperture area than this is available if fallout protection upgrading does not close most of the doors and windows.
- E. Since adequate aperture area is available, no adjustments in airflow are needed.
- F. For the purpose of deploying ventilation equipment, the Bassett Building can be treated as two Configuration IV-A-1 facilities (see Appendix B) placed together in an L-shape.
- G. One Kearny pump is needed as an air mixer in the conference room of the Bassett Building.
- H. Nine 3-foot Kearny pumps are required to supply fresh air to dead-end rooms.
- I. The equipment deployment in the Bassett Building is illustrated in Figure C-6. Fresh air enters apertures throughout the building, and stale air is exhausted through the doors at the west end. The small dead-end rooms that are not ventilated by Kearny pumps should not be used as shelter area. Windows close to the ventilators should be only slightly opened.

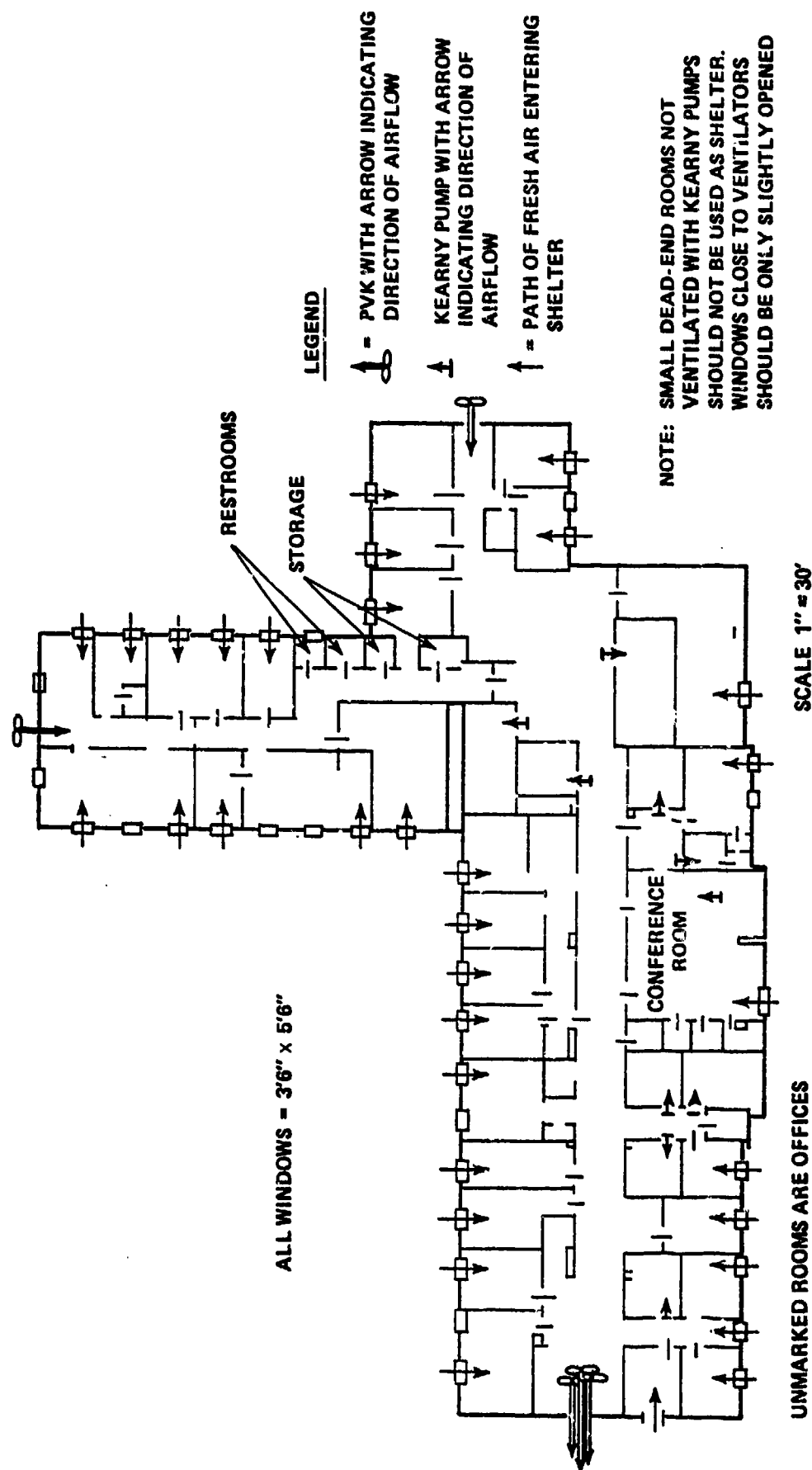


Figure C-3. Ventilation Plan For Bassett Building

APPENDIX D  
SHELTER FACILITY SPECIFICATIONS

APPENDIX D  
SHELTER FACILITY SPECIFICATIONS

This appendix contains tables listing the CRP Facility Number, number of shelter spaces, distance from the county courthouse, and requirements for water containers, commodes, sanitation kits, PVKs and KPKs for each shelter facility by county in the Macon, Georgia host area and by township in the Utica-Rome host area. Each requirement for water containers was estimated on the basis of 1 per 100 shelter spaces, for commodes on the basis of 1 per 5 shelter spaces, and for sanitation kits on the basis of 1 per 50 shelter spaces. The number of PVKs was estimated by determining the required volume of ventilation from the number of shelter spaces and the zonal ventilation requirement and assuming an equivalent duct length of 200 feet in determining the PVK capacity. The number of KPKs is based on the regional ratio of KPKs per 1,000 shelter spaces developed in Chapter 4 and displayed in Table IV-25.

Table D-1. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Houston County, Georgia

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance* From County Courthouse (miles)
7288C	736	8	147	15	4	0	1.7
7289C	947	10	189	19	5	0	1.7
7290C	1,211	12	242	24	7	1	1.7
7091C	864	9	172	17	5	0	1.7
7289C	569	6	113	11	3	0	1.7
7111C	6,825	68	1,365	136	35	2	1.7
7291C	831	8	166	16	5	0	1.7
7294C	764	8	152	15	4	0	1.7
7280C	835	8	167	16	5	0	1.7
7184C	1,240	12	248	24	7	1	1.7
7134C	460	5	92	9	3	0	1.7
7274C	610	6	122	12	4	0	1.7
7271C	1,248	12	249	24	7	1	1.7
7293C	480	5	96	10	3	0	1.7
7275C	879	9	175	17	5	0	1.7
7296C	1,193	12	238	23	6	0	1.7
7299C	2,061	20	412	41	11	1	1.7
7278C	2,167	21	433	43	11	1	1.7
7295C	1,430	14	286	28	8	1	1.7
7177C	955	10	191	19	5	0	1.7
7106C	3,726	37	745	74	19	1	1.7
7189C	1,705	17	341	34	9	1	1.7
7297C	13,135	131	2,627	262	66	4	1.7
7269C	2,165	21	433	43	11	1	1.7
TOTAL	47,036	469	9,401	932	248	15	

\*All of the shelter facilities are located within the county seat and specific locations could not be identified. It was assumed that the facilities are distributed at equal distances from each other about the city limits.

Table D-2. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Twiggs County, Georgia

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
3155C	2,340	23	450	45	12	1	1.1
3158C	4,400	42	840	84	23	2	7
3157C	900	9	180	18	5	0	11.1
3156C	900	9	180	18	5	0	7.9
3154C	805	8	160	16	5	0	15.3
3152C	360	4	80	8	2	0	.1
3137C	344	4	75	7	2	0	.3
3141C	439	5	90	9	3	0	.2
3098C	50	1	15	1	0	0	11.7
3087C	153	2	35	3	1	0	.4
3100C	160	2	40	4	1	0	17.9
3096C	65	1	20	2	1	0	16.6
3103C	110	2	30	3	1	0	5.1
3066C	203	2	45	4	2	0	8.2
3104C	72	1	20	2	1	0	5.2
3105C	48	1	15	1	0	0	5.3
3159C	1,140	11	225	22	6	1	9.5
TOTAL	12,489	127	2,500	247	70	4	

Table D-3. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Peach County, Georgia

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance* From County Courthouse (miles)
13008	495	5	99	10	3	0	1.3
13011	4,550	45	910	91	23	1	1.3
13012	900	9	180	18	5	0	1.3
13014	2,370	23	474	47	12	1	1.3
19003	403	4	80	8	3	0	1.3
19010	387	4	77	8	2	0	1.3
19051	135	2	27	3	1	0	1.3
15006	65	1	13	2	1	0	1.3
19042	1,027	10	205	20	6	1	1.3
15002	272	3	54	6	2	0	1.3
15039	350	4	70	7	2	0	1.3
15037	104	1	20	2	1	0	1.3
15106	133	2	26	3	1	0	1.3
19021	3,264	32	652	65	17	1	1.3
15005	275	3	55	6	2	0	1.3
19011	555	6	111	11	3	0	1.3
19006	700	7	140	14	4	0	1.3
19006	1,050	10	210	21	6	1	1.3
19006	1,170	12	234	23	6	1	1.3
15008	61	1	12	2	1	0	1.3
TOTAL	18,266	184	3,649	367	101	6	

\*All of the shelter facilities are located within the county seat and specific locations could not be identified. It was assumed that the facilities are distributed at equal distance from each other about the city limit.



Table D-4. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Baldwin County, Georgia

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
00391	943	9	188	18	5	0	0.4
00388	707	7	141	14	4	0	0.4
00389	707	7	141	14	4	0	0.4
00390	382	4	76	8	2	0	0.4
00064	2,491	24	498	49	13	1	0.4
00275	688	7	137	14	4	0	0.5
00287	204	2	40	4	2	0	0.5
00357	400	4	80	8	3	0	0.8
00335	433	5	86	9	3	0	0.9
00459	2,860	28	572	57	15	1	2.0
00007	4,990	49	998	99	26	2	.8
00008	1,438	14	287	28	8	0	.8
00009	1,060	11	212	21	6	0	.8
00010	2,154	21	430	43	11	1	.8
00011	1,451	14	290	29	8	0	.8
00214	1,090	11	218	21	6	0	1.0
00215	1,217	12	243	24	7	0	1.0
00216	731	7	146	14	4	0	1.0
00212	994	10	198	19	5	0	1.8
00220	1,938	19	387	38	10	1	1.8
00217	3,442	34	688	68	18	1	1.5
00213	709	7	141	14	4	0	1.5
00436	1,769	17	353	35	9	1	2.3
00437	1,410	14	282	28	8	0	2.3
00397	459	5	91	9	3	0	1.8
00398	1,326	13	265	26	7	0	1.8
00021	1,264	13	252	25	7	0	.5
00017	8,400	84	1,680	168	44	3	.5
00019	787	8	157	15	4	0	.5
00023	841	9	168	17	5	0	.5
00020	130	2	26	3	1	0	.5
00018	114	2	22	3	1	0	.5
00406	39,154	391	7,830	783	206	12	3.8
00405	1,936	19	387	38	10	1	3.8
00343	433	5	86	9	3	0	.9
00206	900	9	180	18	5	0	1.4
00207	4,080	40	816	81	21	2	1.4
00208	31,725	317	6,345	634	166	9	1.4
00209	6,780	67	1,356	135	35	2	1.4
00102	2,415	24	483	48	13	1	2.6
00274	8,499	84	1,699	169	44	3	2.1

(Continued)

Table D-4. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Baldwin County, Georgia (Continued)

CRP Facility Number	Shelter Spaces	Water Containers	Commodities	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
00063	.474	5	94	10	3	0	.5
02917	1,896	19	379	37	10	1	.5
00392	669	7	133	13	4	0	.5
10294	675	7	134	13	4	0	.5
00393	144	2	28	3	1	0	.5
02809	6,868	68	1,373	137	36	2	6.8
02813	3,778	37	755	75	19	1	6.9
02810	15,992	159	3,198	319	84	5	6.7
02811	3,547	35	709	70	18	1	7.1
02812	2,076	20	415	41	11	1	7.2
00526	1,098	11	219	21	6	0	6.5
00527	1,390	14	278	27	7	0	6.5
02815	3,660	36	732	73	19	1	6.4
02808	2,969	29	593	59	15	1	4.5
02805	4,640	46	928	92	24	2	4.9
02806	4,307	43	861	86	22	2	5.0
02807	1,911	19	382	38	10	1	5.3
02817	1,911	19	382	38	10	1	5.3
02818	1,911	19	382	38	10	1	5.3
00493	2,740	27	548	54	14	1	4.2
02804	5,237	52	1,047	104	27	2	4.1
02803	5,237	52	1,047	104	27	2	4.0
02802	4,108	41	821	82	21	1	3.8
00492	1,195	12	239	23	6	0	7.5
00490	10,889	108	2,177	217	57	3	7.6
00481	10,748	107	2,149	214	56	3	5.6
00491	10,872	108	2,174	217	57	3	5.8
TOTAL	254,393	2,531	50,852	5,062	1,338	76	

Table D-5. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Bleckley County, Georgia

CRP Facility Number	Shelter Spaces	Water Containers	Commodities	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
7136C	830	8	166	16	5	0	0.2
7164C	2,250	22	450	45	12	1	0.1
7151C	604	6	120	12	4	0	0.2
7104C	765	8	153	15	4	0	0.1
7129C	648	7	129	13	4	0	0.2
7094C	497	5	99	10	3	0	0.2
7132C	1,080	11	216	21	6	1	0.3
7157C	149	2	29	3	1	0	0.3
7155C	255	3	51	5	2	0	0.1
7110C	1,481	15	296	29	8	1	0.1
7095C	1,517	15	303	30	8	1	0.1
7138C	516	5	103	10	3	0	0.0
7147C	1,742	17	348	34	9	1	0.1
7113C	510	5	102	10	3	0	0.2
7135C	240	3	48	5	2	0	0.2
7165C	600	6	120	12	3	0	0.4
7062C	915	9	183	18	5	0	1.0
7061C	900	9	180	18	5	0	1.2
7060C	1,995	19	399	39	10	1	1.0
7014C	290	3	58	6	2	0	0.8
7055C	620	6	124	12	4	0	0.9
7059C	105	1	21	2	1	0	1.1
7052C	1,200	12	240	24	7	1	.8
70532	55	1	11	2	1	0	1.0
7015C	945	9	189	18	5	0	1.0
TOTAL	20,709	207	4,138	409	117	7	

Table D-6. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Dodge County, Georgia

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
9076C	264	3	52	6	2	0	1.8
9074C	276	3	55	6	2	0	1.8
9071C	1,099	11	219	21	6	0	1.5
9060C	505	5	101	10	3	0	1.5
9014C	499	5	100	10	3	0	0.7
9002C	1,220	12	244	24	7	1	0.7
9028C	1,216	12	243	24	7	1	0.7
9023C	792	8	158	16	4	0	0.7
9020C	478	5	95	10	3	0	0.8
9008C	1,693	17	338	33	9	1	0.8
9005C	798	8	159	16	4	0	0.7
5145C	579	6	115	12	3	0	0.7
5146C	537	6	107	11	3	0	0.7
5147C	384	4	76	8	2	0	0.7
9054C	786	8	157	15	4	0	0.7
9045C	841	8	168	17	5	0	0.7
9046C	515	5	103	10	3	0	0.7
9047C	341	4	68	7	2	0	0.7
9048C	1,496	10	299	29	8	1	0.7
9049C	105	1	21	2	1	0	0.7
9050C	105	1	21	2	1	0	0.7
9090C	45	1	9	1	0	1	0.7
9091C	45	1	9	1	0	1	0.7
9092C	173	2	34	4	1	0	0.7
5156C	458	5	91	9	3	0	3.7
5135C	204	2	40	4	2	0	0.7
5136C	167	2	33	4	1	0	0.7
5006C	646	7	129	13	4	0	0.7
5129C	1,510	15	302	30	8	1	0.7
5130C	84	1	16	2	1	0	0.7
5040C	421	5	84	9	3	0	0.7
5041C	446	5	89	9	3	0	0.7
5099C	1,005	10	201	20	6	0	0.7
5045C	247	3	49	5	2	0	0.7
5078C	378	4	75	8	2	0	0.7
5079C	116	2	23	3	1	0	0.7
5076C	110	2	22	3	1	0	0.7
9051C	105	1	21	2	1	0	0.7
9052C	105	1	21	2	1	0	0.7
TOTAL	20,794	217	4,147	418	122	7	

Table D-7. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Laurens County, Georgia

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
1006C	5,100	51	1,020	102	27	2	5.1
1018C	4,165	42	833	83	22	1	5.1
1016C	711	7	142	14	4	0	3.8
1016C	160	2	32	3	1	0	3.8
1016C	145	2	29	3	1	0	3.8
1016C	126	1	25	3	1	0	3.8
1016C	102	1	20	2	1	0	3.8
1016C	178	2	36	4	1	0	3.8
8080C	315	3	63	6	2	0	2.2
8048C	110	1	22	2	1	0	8.8
1021C	900	9	180	18	5	0	4.5
8023C	240	2	48	5	2	0	3.9
8063C	60	1	12	1	1	0	2.3
1109C	92	1	18	2	1	0	3.1
1110C	178	2	36	4	1	0	3.1
1112C	178	2	36	4	1	0	3.1
1113C	178	2	36	4	1	0	3.1
1114C	178	2	36	4	1	0	3.1
1115C	210	2	42	4	2	0	3.1
4149C	204	2	41	4	2	0	12.3
4159C	170	2	34	3	1	0	9.3
4151C	306	3	61	6	2	0	9.6
4150C	115	1	23	2	1	0	10.3
4162C	74	1	15	2	1	0	6.4
1002C	4,275	43	855	86	23	1	1.5
1002C	3,530	35	705	71	19	1	1.5
1002C	745	8	149	15	4	0	1.5
1001C	530	5	106	11	3	0	1.5
1005C	3,260	33	652	65	18	1	1.6
1008C	1,955	20	391	39	11	1	1.7
2001C	6,729	67	1,346	135	35	2	1.8
2001C	1,923	19	385	39	11	1	1.8
2001C	4,606	46	921	92	25	1	1.8
2003C	830	8	166	17	5	0	1.9
2003C	384	4	77	8	3	0	1.9
2003C	446	5	89	9	3	1	1.9
2004C	1,037	10	207	21	6	1	2.0
2004C	560	6	112	11	3	0	2.0
8033C	260	3	52	5	2	0	2.8
2004C	777	5	95	10	3	0	2.1
1007C	879	9	175	18	5	0	2.2
2002C	1,009	10	174	17	6	1	2.3

(Continued)

Table D-7. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Laurens County, Georgia (Continued)

CRP Facility Number	Shelter Spaces	Water Containers	Commodities	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
2002C	869	9	28	3	5	0	2.3
2002C	140	1	28	3	1	0	2.3
2005C	2,023	20	405	41	11	1	2.4
4064C	56	1	11	1	1	0	2.5
1003C	2,173	22	435	44	12	1	2.6
1004C	1,500	15	300	30	8	1	2.7
1010C	1,540	15	308	31	9	1	2.8
2095C	355	4	71	7	2	0	2.9
2094C	309	3	62	6	2	0	3.0
2098C	310	3	62	6	2	0	3.1
8164C	243	2	49	5	2	0	3.2
8163C	99	1	20	2	1	0	3.3
8182C	580	6	116	12	4	0	3.4
1012C	3,991	40	798	80	22	1	2.8
1013C	9,296	93	1,859	186	49	3	2.8
1019C	2,973	30	595	60	16	1	9.1
1019C	928	9	186	19	5	0	9.1
1019C	928	9	186	19	5	0	9.1
1019C	913	9	182	18	5	0	9.1
1019C	102	1	20	2	1	0	9.1
1019C	102	1	20	2	1	0	9.1
1014C	1,865	19	373	37	10	1	9.2
2247C	135	1	27	3	1	0	10.8
8014C	200	2	40	4	2	0	4.5
2249C	234	2	47	5	2	1	13.3
1028C	1,441	14	288	29	8	1	12.7
1028C	446	5	89	9	3	0	12.7
1028C	995	10	199	20	6	1	12.7
2122C	582	6	116	12	4	0	13.0
4168C	204	2	41	4	2	0	5.9
2041C	158	2	32	3	1	0	3.6
2045C	394	4	79	8	3	0	3.7
2076C	921	9	184	18	5	0	3.8
2082C	146	2	29	3	1	0	3.9
2081C	198	2	40	4	2	0	4.0
2099C	230	2	46	5	2	0	4.0
2101C	110	1	22	2	1	0	4.1
2228C	260	3	52	5	2	0	4.2
4009C	650	7	130	13	4	0	4.3
1009C	7,721	77	1,544	154	41	2	4.4
1039C	784	8	157	16	5	0	4.4

(Continued)

Table D-7. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Laurens County, Georgia (Continued).

CRP Facility Number	Shelter Spaces	Water Containers	Commodities	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
1017C	1,664	17	333	33	9	1	4.5
1017C	924	9	185	19	5	0	4.5
1017C	350	4	70	7	2	0	4.5
1017C	390	4	78	8	3	0	4.5
1011C	5,033	50	1,007	101	27	2	4.5
1011C	1,277	13	255	26	7	1	4.5
1011C	2,710	27	542	54	15	1	4.5
1011C	1,046	11	209	21	6	1	4.5
4105C	100	1	20	2	1	0	4.6
4135C	240	2	48	5	2	0	14.6
4077C	160	2	32	3	1	0	3.4
8047C	84	1	17	2	1	0	12.1
TOTAL	108,712	1,093	21,570	2,166	616	35	

Table D-8. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Monroe County, Georgia

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
2001C	1,178	12	235	23	6	0	1.6
2002C	541	6	108	11	3	0	1.6
2004C	675	7	135	13	4	0	1.6
2003C	342	4	68	7	2	0	1.6
4132C	192	2	38	4	1	0	2.3
4129C	2,250	22	450	45	12	1	1.6
2006C	4,859	48	971	97	26	2	0.4
6004C	1,476	15	295	29	8	1	0.5
6007C	300	3	60	6	2	0	0.5
6008C	525	5	105	10	3	0	0.5
6010C	135	2	27	3	1	0	0.5
6012C	1,210	12	242	24	7	0	0.5
4168C	102	1	20	2	1	0	0.5
4169C	1,591	16	318	31	8	1	0.5
4170C	302	3	60	6	2	0	0.5
4224C	1,476	15	295	29	8	1	1.2
4225C	756	8	151	15	4	0	1.2
4217C	415	4	83	8	3	0	0.9
4222C	720	7	144	14	4	0	0.9
4223C	1,422	14	284	28	8	1	0.9
4204C	352	4	70	7	2	0	1.0
4199C	648	7	129	13	4	0	0.9
4200C	320	4	64	7	2	0	0.9
4201C	340	4	68	7	2	0	0.9
4203C	382	4	76	8	2	0	0.9
4181C	1,232	12	246	24	7	0	0.8
4177C	680	7	136	13	4	0	0.7
4178C	680	7	136	13	4	0	0.7
4179C	816	8	163	16	5	0	0.7
4173C	1,488	15	297	29	8	1	0.7
4193C	150	2	30	3	1	0	0.9
2012C	4,137	41	827	82	22	1	1.2
4194C	272	3	54	6	2	0	0.1
6006C	392	4	78	8	2	0	0.5
6005C	640	7	128	13	4	0	0.5
6003C	634	7	126	13	4	0	0.5
6002C	691	7	138	14	4	0	0.5
6001C	634	7	126	13	4	0	0.5
2005C	398	4	79	8	2	0	0.3
2006C	270	3	54	6	2	0	0.5
4187C	190	2	38	4	1	0	0.1

(Continued)



Table D-8. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Monroe County, Georgia (Continued)

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
4188C	400	4	80	8	2	0	0.1
05101	1,351	13	270	27	7	1	0
05107	77	1	15	2	1	0	0.1
05112	78	1	15	2	1	0	0.1
05114	235	3	47	5	2	0	0.1
05121	28	1	6	1	0	1	0.1
05123	28	1	6	1	0	1	0.8
TOTAL	38,010	389	7,591	758	214	12	

Table D-9. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Pulaski County, Georgia

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
6208C	816	8	163	16	5	0	0.7
6014C	1,189	12	232	23	6	1	1.8
6210C	4,690	46	938	93	24	2	1.1
6012C	3,408	34	681	68	18	1	1.6
6003C	2,667	26	533	53	14	1	1.8
6149C	385	4	77	8	2	0	0.4
6049C	630	6	126	12	4	0	0.3
6097C	780	8	156	15	4	0	0.4
6095C	2,400	24	480	48	13	1	0.4
6011C	750	8	150	15	4	0	0.5
6065C	315	3	63	6	2	0	0.2
6071C	976	10	195	19	5	0	0.1
6064C	723	7	144	14	4	0	0.1
6132C	560	6	112	11	3	0	0.6
6017C	582	6	116	12	3	0	0.1
6177C	450	5	90	9	3	0	0.5
6207C	5,207	52	1,041	104	27	2	0.5
TOTAL	26,499	264	5,297	525	141	8	

Table D-10. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Verono Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
1020C	170	2	34	4	1	0	19.8
1021C	200	2	40	4	1	1	19.8
1048C	190	2	38	4	1	1	29.9
1006C	100	1	20	2	1	0	22.8
1300C	2,107	21	421	42	6	5	19.8
1049C	405	4	81	8	2	0	29.5
1298C	27	1	6	1	0	1	19.8
1301C	20	1	4	1	0	1	19.8
TOTAL	3,219	34	644	66	12	9	

Table D-11. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Annsville Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodities	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
1222C	90	1	18	2	1	1	23.6
1215C	56	1	11	2	1	0	21.5
TOTAL	146	2	29	4	2	1	

Table D-12. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Avo Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodes	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
1001C	44	1	9	1	0	1	29.0
TOTAL	44	1	9	1	0	1	

Table D-13. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Camden Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodes	Sanitation Kits	PVKs	KPKs	Distance* From County Courthouse (miles)
1003C	366	4	73	7	1	2	29.8
1005C	70	1	14	2	1	0	29.8
1007C	83	1	16	2	1	0	29.8
1008C	217	3	43	5	1	1	29.8
1242C	62	1	12	2	1	0	29.8
1248C	332	4	66	7	1	2	29.8
1250C	48	1	10	1	0	1	29.8
1251C	465	5	93	9	2	2	29.8
1281C	352	4	70	7	1	2	29.8
1294C	120	2	24	3	1	0	29.8
1237C	42	1	8	1	0	1	28.3
1240C	248	3	49	5	1	1	28.3
1245C	54	1	11	2	0	1	28.3
1255C	130	2	26	3	1	0	28.3
1371C	252	3	50	5	1	1	29.8
1285C	2,010	20	402	40	6	8	29.8
1257C	107	2	21	3	1	0	29.8
1258C	89	1	17	2	1	0	29.8
1259C	160	2	32	4	1	1	29.8
1260C	297	3	59	6	1	1	29.8
1261C	116	2	23	3	1	0	29.8
1262C	73	1	14	2	1	0	29.8
1264C	72	1	14	2	1	0	29.8
1267C	85	1	17	2	1	0	29.8
1269C	96	1	19	2	1	0	29.8
1271C	163	2	32	4	1	1	29.8
1272C	50	1	10	1	0	1	29.8
1274C	70	1	14	2	1	0	29.8
1275C	83	1	16	2	1	0	29.8
1276C	130	2	26	3	1	0	29.8
1277C	129	2	26	3	1	0	29.8
1279C	70	1	14	2	1	0	29.8
1280C	75	1	15	2	1	0	29.8
1282C	38	1	8	1	0	1	29.8
1283C	389	4	77	8	1	2	29.8
1286C	58	1	12	2	1	0	29.8
1287C	137	2	27	3	1	1	29.8
1263C	102	1	20	2	1	0	29.8
1265C	60	1	12	2	1	0	29.8
1266C	60	1	12	2	1	0	29.8
1268C	59	1	12	2	1	0	29.8

(Continued)

Table D-13. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Camden Township, Oneida County, New York (Continued)

CRP Facility Number	Shelter Spaces	Water Containers	Commodes	Sanitation Kits	PVKs	KPKs	Distance* From County Courthouse (miles)
1270C	55	1	11	2	1	0	29.8
1273C	10	1	2	1	0	1	29.8
1278C	97	1	19	2	1	0	29.8
1288C	32	1	7	1	0	1	29.8
1289C	119	2	23	3	1	0	29.8
1290C	36	1	7	1	0	1	29.8
1291C	199	2	39	4	1	1	29.8
1292C	70	1	14	2	1	0	29.8
1293C	33	1	7	1	0	1	29.8
1431C	170	2	34	4	1	1	29.8
1432C	88	1	17	2	1	0	29.8
1217C	330	4	66	7	1	1	29.8
TOTAL	8,858	111	1,762	198	51	37	

\*Specific shelter facility locations could not be identified within Camden Township. Distance measured from county courthouse to center of Camden Township.

Table D-14. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Vienna Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodores	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
1178C	420	4	84	8	2	1	28.9
1216C	850	9	170	17	3	2	31.9
1296C	90	1	18	2	1	1	31.9
TOTAL	1,360	14	272	27	6	4	



Table D-15. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Florence Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodities	Sanitation Kits	PVKs	KPKs	Distance* From County Courthouse (miles)
1218C	70	1	14	2	1	0	35.8
1223C	116	2	23	3	1	1	35.8
1228C	124	2	24	3	1	1	35.8
1229C	112	2	22	3	1	1	35.8
TOTAL	422	7	83	11	4	3	

\*Specific shelter facility locations could not be identified within Florence Township. Distance measured from county courthouse to center of Florence Township.

Table D-16. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Lee Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
01459	240	3	48	5	1	1	20.8
01460	135	2	27	3	1	0	20.8
01461	300	3	60	6	1	1	20.8
01462	150	2	30	3	1	0	20.8
01466	56	1	11	2	1	0	20.8
01468	300	3	60	6	1	1	20.8
01479	85	1	17	2	1	0	20.8
01486	170	2	34	4	1	0	20.8
01489	320	4	64	7	1	1	20.8
01491	70	1	14	2	1	0	20.8
01493	50	1	10	1	0	1	20.8
01494	50	1	10	1	0	1	20.8
01499	60	1	12	2	1	0	22.3
01500	63	1	12	2	1	0	22.3
01501	168	2	33	4	1	0	22.3
01502	180	2	36	4	1	1	22.3
01503	190	2	38	4	1	1	22.3
01504	420	4	84	8	2	2	22.3
01506	331	4	66	7	1	1	22.3
01507	20	1	4	1	0	1	22.3
01508	120	2	24	3	1	0	22.3
01516	90	1	18	2	1	0	22.3
01512	90	1	18	2	1	0	22.3
01517	35	1	7	1	0	1	25.3
03758	2,420	24	484	48	7	7	25.3
TOTAL	6,113	70	1,221	130	28	20	

Table D-17. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Boonville Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance* From County Courthouse (miles)
1114C	64	1	13	2	1	0	30.8
1121C	72	1	14	2	1	0	30.8
1127C	132	2	26	3	1	1	30.8
1346C	142	2	28	3	1	1	30.8
1361C	75	1	15	2	1	0	30.8
1366C	72	1	14	2	1	0	30.8
1434C	218	3	43	4	1	1	30.8
1440C	71	1	14	2	1	0	30.8
1443C	158	2	31	4	1	1	30.8
1444C	160	2	32	4	1	1	30.8
1445C	120	2	24	3	1	1	30.8
1449C	144	2	28	3	1	1	30.8
1441C	95	1	19	2	1	1	30.8
1447C	928	9	185	18	3	4	30.8
1342C	306	3	61	6	1	1	30.8
1344C	64	1	13	2	1	0	30.8
1345C	70	1	14	2	1	0	30.8
1347C	90	1	18	2	1	1	30.8
1348C	93	1	18	2	1	1	30.8
1349C	50	1	10	1	0	1	30.8
1350C	64	1	13	2	1	0	30.8
1351C	70	1	14	2	1	0	30.8
1352C	315	3	63	6	1	1	30.8
1353C	209	2	41	4	1	1	30.8
1354C	64	1	13	2	1	0	30.8
1355C	83	1	16	2	1	1	30.8
1356C	11	1	3	1	0	1	30.8
1357C	90	1	18	2	1	1	30.8
1358C	72	1	14	2	1	0	30.8
1359C	75	1	15	2	1	0	30.8
1360C	73	1	14	2	1	0	30.8
1362C	54	1	11	2	1	0	30.8
1363C	445	5	89	9	2	2	30.8
1364C	18	1	4	1	0	1	30.8
1365C	368	4	73	8	1	2	30.8
1367C	149	2	30	3	1	1	30.8

(Continued)

Table D-17. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Boonville Township, Oneida County, New York (Continued)

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance* From County Courthouse (miles)
1368C	317	4	63	7	1	1	30.8
1433C	182	2	36	4	1	1	30.8
1435C	130	2	26	3	1	1	30.8
1442C	80	1	16	2	1	0	30.8
1446C	60	1	12	2	1	0	30.8
1448C	160	2	32	4	1	1	30.8
1459C	78	1	15	2	1	0	30.8
TOTAL	6,291	78	1,251	143	43	31	

\*Specific shelter facility location could not be identified within Boonville Township. Distance measured from county courthouse to center of Boonville Township.

Table D-18. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Trenton Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodities	Sanitation Kits	PVKs	KPKs	Distance* From County Courthouse (miles)
1128C	78	1	15	2	1	0	16.0
1130C	120	2	24	3	1	1	16.0
1131C	60	1	12	2	1	0	16.0
1132C	202	2	40	4	1	1	16.0
1133C	122	2	24	3	1	1	16.0
1369C	95	1	19	2	1	1	16.0
TOTAL	677	9	134	16	6	4	

\*Specific shelter facility locations could not be identified within Trenton Township. Distance measured from county courthouse to center of Trenton Township.

Table D-19. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Remsen Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodities	Sanitation Kits	PVKs	KPKs	Distance* From County Courthouse (miles)
1089C	42	1	8	1	0	1	17.5
1090C	84	1	16	2	1	0	17.5
1091C	50	1	10	1	0	1	17.5
1209C	21	1	4	1	0	1	17.5
1211C	70	1	14	2	1	0	17.5
1213C	64	1	13	2	1	0	17.5
1322C	1,266	13	253	25	4	5	17.5
1323C	332	4	66	7	1	1	17.5
1335C	144	2	28	3	1	0	17.5
1411C	350	4	70	7	1	1	17.5
1336C	73	1	14	2	1	0	17.5
1334C	54	1	11	2	1	0	17.5
1338C	140	2	28	3	1	1	17.5
1339C	103	1	20	2	1	0	17.5
1340C	64	1	13	2	1	0	17.5
1341C	121	2	24	3	1	1	17.5
TOTAL	2,978	37	592	65	16	12	

\*Specific shelter facility locations could not be identified within Remson Township. Distance measured from county courthouse to center of Remson Township.

Table D-20. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Forestport Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodes	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
1098C	100	1	20	2	1	1	28.0
1100C	100	1	20	2	1	1	28.0
1103C	175	2	35	4	1	1	28.0
1095C	144	2	28	3	1	1	24.5
1096C	24	1	5	1	0	1	24.5
1333C	67	1	13	2	1	0	28.8
1324C	73	1	14	2	1	0	28.8
1325C	140	2	28	3	1	1	28.8
1326C	141	2	28	3	1	1	28.8
1327C	92	1	18	2	1	0	28.8
1329C	76	1	15	2	1	0	28.8
1330C	105	1	21	2	1	1	28.8
1331C	64	1	13	2	1	0	28.8
1332C	100	1	20	2	1	1	28.8
TOTAL	1,401	18	278	32	13	9	

Table D-21. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Paris Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodes	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
00749	2,021	20	404	40	6	4	8.8
00751	1,200	12	240	24	4	3	11.1
00753	1,250	12	250	25	4	2	11.1
00860	2,886	28	577	57	8	6	11.1
02233	4,000	40	800	80	11	9	8.1
TOTAL	11,357	112	2,271	226	33	24	



Table D-22. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Sangerfield Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance* From County Courthouse (miles)
1383C	73	1	14	2	1	0	12.0
1385C	32	1	7	1	0	1	12.0
1390C	250	3	50	5	1	1	12.0
1391C	336	4	67	7	1	1	12.0
1403C	74	1	15	2	1	1	12.0
1405C	320	4	64	7	1	1	12.0
1414C	64	1	13	2	1	0	12.0
1415C	64	1	13	2	1	0	12.0
1416C	38	1	8	1	0	1	12.0
1417C	211	3	42	5	1	1	12.0
1419C	450	5	90	9	2	1	12.0
1420C	150	2	30	3	1	1	12.0
1393C	386	4	77	8	1	1	12.0
1394C	514	5	102	10	2	1	12.0
1404C	94	1	18	2	1	1	12.0
1406C	195	2	39	4	1	1	12.0
1412C	700	7	140	14	2	1	12.0
1413C	192	2	38	4	1	1	12.0
1421C	149	2	29	3	1	1	12.0
1422C	58	1	12	2	1	0	12.0
1423C	89	1	17	2	1	1	12.0
1424C	63	1	12	2	1	0	12.0
1425C	54	1	11	2	1	0	12.0
TOTAL	4,556	54	908	99	24	17	

\*Specific shelter facility locations could not be identified within Sangerfield Township. Distance measured from county courthouse to center of Sangerfield Township.

Table D-23. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Marshall Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodities	Sanitation Kits	PVKs	KPKs	Distance* From County Courthouse (miles)
1073C	464	5	92	9	2	1	12.9
1074C	141	2	28	3	1	1	12.9
1075C	105	1	21	1	1	1	12.9
TOTAL	710	8	141	13	4	3	

\*Specific shelter facility location could not be identified within Marshall Township. Distance measured from county courthouse to center of Marshall Township.

Table D-24. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Bridgewater Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance* From County Courthouse (miles)
1426C	37	1	8	1	0	1	14.0
1427C	36	1	7	1	0	1	14.0
1428C	80	1	16	2	1	0	14.0
1430C	80	1	16	2	1	0	14.0
1455C	144	2	28	3	1	1	14.0
1320C	79	1	16	2	1	0	14.0
1321C	140	2	28	3	1	1	14.0
1343C	100	1	20	2	1	1	14.0
TOTAL	696	10	139	16	6	5	

\*Specific shelter facility locations could not be identified within Bridgewater Township. Distance measured from county courthouse to center of Bridgewater Township.

Table D-25. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Augusta Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodities	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
1081C	197	2	39	4	1	1	18.2
1082C	202	2	40	4	1	1	18.2
1083C	260	3	52	5	1	1	18.2
1186C	130	2	26	3	1	1	18.2
1187C	290	3	58	6	1	1	18.2
1188C	80	1	16	2	1	0	22.7
1189C	28	1	6	1	0	1	18.2
1190C	78	1	15	2	1	0	18.2
1192C	78	1	15	2	1	0	18.2
1193C	78	1	15	2	1	0	18.2
1318C	1,348	13	269	26	4	2	18.2
1317C	315	3	63	6	1	2	18.2
1080C	135	2	27	3	1	1	18.2
1319C	107	2	21	3	1	1	22.7
TOTAL	3,326	37	662	69	16	12	

Table D-26. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Verron Township, Oneida County, New York

CRP Facility Number	Shelter Spaces	Water Containers	Commodos	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
1027C	70	1	14	2	1	0	17.3
1042C	454	5	90	9	2	1	17.3
1173C	75	1	15	2	1	0	17.3
1161C	108	2	21	3	1	0	24.9
1163C	280	3	56	6	1	1	24.9
1166C	100	1	20	2	1	0	24.9
1179C	241	3	48	5	1	1	21.8
1181C	192	2	38	4	1	0	21.8
1304C	4,500	45	900	90	12	13	24.9
1306C	72	1	14	2	1	0	24.9
1307C	60	1	12	2	1	0	17.6
1308C	425	5	85	9	2	1	24.9
1373C	1,920	19	384	38	5	5	24.9
1374C	210	2	42	4	1	1	24.9
1375C	616	6	123	12	2	2	24.9
1376C	128	2	25	3	1	0	24.9
1379C	226	3	45	5	1	1	21.8
1011C	288	3	57	6	1	1	21.8
21029	70	1	14	2	1	0	17.3
1040C	644	7	128	13	2	2	17.3
1041C	88	1	17	2	1	0	17.3
1054C	61	1	12	2	1	0	17.3
1056C	34	1	7	1	0	1	17.3
1057C	94	1	18	2	1	0	17.3
1058C	232	3	46	5	1	1	17.3
1059C	78	1	15	2	1	0	17.3
1061C	20	1	4	1	0	1	17.3
1063C	148	2	29	3	1	0	17.3
1064C	70	1	14	2	1	0	15.8
1067C	35	1	7	1	0	1	17.3
1068C	77	1	15	2	1	0	17.3
1070C	277	3	55	6	1	1	17.3
1160C	103	1	20	3	1	0	24.9
1169C	70	1	14	2	1	0	24.9
1185C	171	2	34	4	1	0	17.3
1313C	56	1	11	2	1	0	17.3
1451C	134	2	26	3	1	0	17.3
1372C	41	1	8	1	0	1	18.8
1183C	2,916	29	583	58	8	8	17.3
1184C	1,527	15	305	30	4	4	17.3
1303C	104	1	20	2	1	0	17.3

(Continued)

Table D-26. Required Supplies and Distance from County Courthouse for Each Shelter Facility in Verron Township, Oneida County, New York (Continued)

CRP Facility Number	Shelter Spaces	Water Containers	Commodes	Sanitation Kits	PVKs	KPKs	Distance From County Courthouse (miles)
1314C	262	3	52	5	1	1	17.3
1315C	27	1	6	1	0	1	17.3
1316C	24	1	5	1	0	1	17.3
1380C	60	1	12	2	1	0	17.3
1381C	67	1	13	2	1	0	17.3
1309C	70	1	14	2	1	0	17.3
TOTAL	17,525	191	3,493	366	70	50	

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RESEARCH TRIANGLE INSTITUTE, Research Triangle Park, North Carolina  
Final Report RTI/703/00-00F  
FEMA Contract No. DCPA01-78-C-0318  
Study of Fallout Shelter Ventilation Kit Placement Design  
S. B. York, III, and J. G. Armstrong  
May 1980 (UNCLASSIFIED) 195 Pages

This study consisted of an investigation into several aspects of providing ventilation in host-area fallout shelter facilities. A stepwise procedure for allocating ventilation equipment to host-area shelter facilities and for deploying the equipment within each facility was developed. Example deployment plans for numerous shelter story configurations and sizes are included as an appendix. Another appendix contains examples in the use of the stepwise procedure to allocate ventilation equipment to and deploy the equipment within six specific shelter facilities.

Also, ratios of the numbers of PWKs and Kearny pumps needed per 1,000 shelter spaces were developed for each DCPA Region. These ratios could be used to estimate the numbers of PWKs and Kearny pumps required if it is necessary to make procurements and identify warehouse space for a host area before detailed ventilation plans for each shelter facility in that host area have been completed.

In addition, alternative systems for distributing shelter supplies from the host-area county seat to individual shelter facilities were evaluated. Analysis of alternative distribution methods in the Macon, Georgia, and Utica-Rome, New York, host areas indicated that the one truck per shelter facility loaded on the basis of the largest facility first priority method generally should be favored. The logistics involved in implementing this method and the advance planning required were discussed.

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DETACHABLE SUMMARY

FINAL REPORT RTI/1703/00-08F

May 1980

Study of Fallout Shelter Ventilation Kit Placement Design

by

S. B. York, III and J. G. Armstrong

for

FEDERAL EMERGENCY MANAGEMENT AGENCY  
OFFICE OF MITIGATION AND RESEARCH  
Washington, D.C. 20472

under

Contract No. DCPA01-78-C-0318  
FEMA Work Unit 1217G

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## SUMMARY

### I. INTRODUCTION AND OBJECTIVES

Recent civil defense thinking has focused on the concept of crisis relocation planning, under which the residents of localities likely to receive direct nuclear weapons effects would be evacuated to outlying host areas that are largely rural in nature. Since few National Shelter Survey (NSS) spaces have been identified in host-area facilities, many people would be sheltered in non-NSS facilities in which the fallout protection would be expediently upgraded. Due to this fact and to results during the last few years of both research and experimental studies into the use of manually powered ventilation equipment, many of the findings of early research into crisis-implemented ventilation systems are in need of reevaluation and updating.

The major objectives of this study are to develop procedures for allocating and deploying Packaged Ventilation Kits (PVKs) and Kearny Pump Kits (KPKs) in host-area fallout shelters and to define and evaluate systems for distributing shelter supplies from host-area county seats to individual fallout shelters. Secondary objectives are to develop methods for determining the numbers of PVKs and KPKs required by a host area before it has been surveyed and to evaluate the usefulness of data from the Crisis Relocation Planning (CRP) Host Areas Facility Survey for planning ventilation systems in particular fallout shelters.

### II. VENTILATION KIT ALLOCATION AND DEPLOYMENT METHODOLOGY

A stepwise procedure is presented for allocating ventilation equipment to host-area fallout shelters and for deploying the equipment within the

shelters. Examples illustrating the effect of various room and aperture configurations and different shelter story sizes are presented in Appendix B. Instructions include direction, first, in the use of PVKs to supply fresh air and to aid in air distribution and, second, in the use of Kearny pumps to supply air to small shelter stories (50 occupants or less) and dead-end rooms or to distribute air in large open areas. The allocation and deployment methodology emphasizes minimizing the number of ventilators needed.

### III. DETERMINATION OF REGIONAL VENTILATOR REQUIREMENTS

Ratios are developed for the numbers of PVKs and Kearny pumps required per 1,000 shelter spaces in each Defense Civil Preparedness Agency (DCPA) Region. The following factors are included in developing these ratios:

- The number of people to be sheltered
- The distribution of shelter stories by room configuration
- The Regional distribution of shelter stories by size
- The Regional percentage of shelter stories in basements and first floors
- The distribution of shelter stories by zonal ventilation requirement.

### IV. EVALUATION OF DISTRIBUTION SYSTEMS FOR FALLOUT SHELTER SUPPLIES

Alternative systems for distributing fallout shelter supplies from the host-area county seat to individual host-area shelter facilities are evaluated on the basis of the time required to deliver supplies to all of the shelters in a county. Two different methods of delivering supplies directly from the county seat to the individual shelters are evaluated. These methods are to use a different truck (loaded on the basis of the largest shelter first, or

the greatest distance first, priority system) to service each shelter facility or to use one truck (or group of trucks) to deliver supplies to all of the shelters in a county or to one zone of a county. A sample of two host areas (the Macon, Georgia, and Utica-Rome, New York, host areas) is used in evaluating the alternative distribution systems. Standard material handling data are used in estimating the time required to deliver supplies.

## V. CONCLUSIONS

In developing the ventilation kit allocation and deployment methodology for host-area shelters, it was determined that the CRP Host Areas Facility Survey data are of limited usefulness in developing general or specific allocation and deployment plans. Sketches of each host-area facility showing details such as interior partitions, apertures in exterior walls, interior doorways, stairwells, and elevator shafts are needed.

The Regional ratios of PVKs and Kearny pumps required per 1,000 shelter spaces display a great deal of Regional variation, caused mostly by differences in zonal ventilation requirements. These large Regional differences must be recognized in making procurements and in identifying warehouse space before procurements are made.

The evaluation of distribution systems for fallout shelter supplies indicates that, in delivering supplies from the county seat to individual shelter sites, one truck (loaded on the basis of the largest facility first priority system) per shelter facility should be used. This method will result in a total distribution time that is the minimum or not significantly greater than the minimum.